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John Bird del.

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VIEW OF THE REMARKABLE BREAK IN THE STRATA AT PEAK

See P.145.

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A

GEOLOGICAL SURVEY

OF THE

Yorkshire Coast:

DESCRIBING THE STRATA AND FOSSILS OCCURRING BETWEEN THE HUMBER AND THE TEES, FROM THE GERMAN OCEAN TO THE PLAIN OF YORK:

Illustrated with numerous Engravings:

By the Rev. George Young, A. M., and John Bird, Artist.

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ERRATA.

Page 52, line 14, *for* lamina, *read* laminæ
56, — 2, Same error.
161, — 10, *for* sandstone, *read* red sandstone
216, — 24, *for* shells, *read* shell
228, — 23, *for* tretraedra, *read* tetraedra
313, — 28, *for* it, *read* they
322, — 19, *for* 1816, *read* 1814.

*** In the list of Organic Remains, it ought to have been noticed, that small beetles are occasionally found among the vegetables in the coal shale. In a specimen which the authors procured at Danby coal pits, is one of these insects, with greenish black glossy wings

INTRODUCTION.

THE science of GEOLOGY proposes to investigate the nature and properties of the different rocks, and other masses, that compose the crust of our globe; to examine their order and positions; to consider the various phenomena which they present, and the changes which they appear to have undergone; and in short, to inquire into every thing calculated to elucidate the structure of the earth.

This study, though less attractive than the pursuits of the astronomer, has an equal claim to our attention. There is something, indeed, peculiarly fascinating in the contemplation of those bright orbs which bespangle the sky; and the imagination more willingly attends the understanding, in soaring through the regions of immeasurable space, and surveying the magnitudes, stations, and motions of the heavenly bodies, than in viewing the features, and exploring the depths, of the earth on which we tread. Not only the celestial regions, but the animal and vegetable kingdoms, possess more charms than the province of geology can boast. Yet this science, fewer as its attractions are, is by no means uninteresting, or unimportant. While we study the laws which govern the remotest planets, shall we remain ignorant of the planet which we inhabit? Shall distant objects engross our attention, to the exclusion of those

which are more within our reach? Or shall we bestow so much care and labour on the animated inhabitants of our globe, and never examine the structure of their dwelling?

The researches of the geologist are far from being unworthy of the christian, or the philosopher: for, while they enlarge the bounds of our knowledge, and present a wide field for intellectual employment and innocent pleasure, they may serve to conduct us to that glorious Being, "who by his strength setteth fast the mountains, being girded with power; in whose hand are the deep places of the earth, and the strength of the hills." All his works praise him, the humblest as well as the grandest; and we see his wisdom and power and goodness, not only in the luminaries of heaven, and in animated nature, but also in the rugged rocks, the stones of the brook, and the clods of the valley.

It is rather surprising, that a study of such importance as geology, has hitherto had so small a share among scientific pursuits. At a very remote period, men began to penetrate into the bowels of the earth, in quest of the shining metals, and other valuable products of the mineral kingdom; and the attention of the learned, both in ancient and modern times, has oft been directed to the nature and classification of minerals: but, till near the beginning of the present century, few philosophers attempted to investigate the structure of the earth itself; and the few who pushed their inquiries in that direction, chose rather to indulge in wild conjectures, than to enter on a sober and patient examination of facts. It is within the last twenty or thirty years, that geology has begun to assume her proper rank among the sciences; and, desisting in a great measure from the flights of fancy, has been proceeding in the more legitimate track of laborious research. Imagination, indeed, can scarcely be altogether restrained from offering her services, in a pursuit where there is so much that is mysterious or obscure; yet, if her wanderings prove a

stimulus to exertion, producing a larger accumulation of facts, and a closer investigation of existing appearances, they will forward, rather than retard, the progress of real knowledge; and, though they occasion a few partial aberrations, they will ultimately subserve the interests of science.

Within these few years, the collection of geological facts has been rapidly accumulating. Still, if we may judge from the jarring opinions held on the subject, we have not obtained sufficient data, for establishing a general theory of the earth; in other words, we cannot satisfactorily explain the natural causes, employed by the Creator to bring our globe into its present state; which, as all agree, is widely different from its original state. The chief thing to be done, therefore, in the present stage of the science, is to enrich it with ample stores derived from actual observation; to collect information concerning the characters, and relative positions, of the substances composing the solid part of the globe; to specify their arrangement, extent, and localities; and notice such hints as they may furnish for elucidating the history of our planet. Every addition to these stores, will serve to enlarge and consolidate the basis, on which a true theory of the earth, if such can be found, must necessarily rest.

It must be remembered, however, that here, as in other departments of science, there are boundaries which we cannot pass; and when our researches shall have been pushed to their utmost limit, it will still be found, that what we know, bears but a small proportion to what we know not. As the astronomer, in exploring the celestial regions, is lost in immeasurable heights, so the geologist, conducting his pursuits in an opposite direction, is soon lost in unfathomable depths. After examining every accessible portion of the globe, and penetrating into the bowels of the earth as far as is practicable by human labour, and collecting all the information within our reach, we shall still be totally ignorant of the interior of our planet, and can no

more pretend to decide what it is composed of, than we can tell the composition of an egg, by probing half way through its shell. The internal structure of this orb, allotted for our residence, is known only to Him who framed it, or to beings of an order superior to man. "Hast thou entered into the springs of the sea? or hast thou walked in the search of the depth? Have the gates of death been opened unto thee? or hast thou seen the doors of the shadow of death? Hast thou perceived the breadth of the earth? Declare if thou knowest it all." The more we learn, the more we may be sensible of our ignorance. If we would fully comprehend any portion of the works of Deity, we must wait till we arrive at a higher sphere of existence.

Yet we must not abandon our inquiries as hopeless and unprofitable, because there are limits beyond which we cannot carry them. If we cannot proceed so far as we might wish, let us not stop short in despair, but advance as far as we can; especially as the boundary of our research may prove to be more distant than was at first anticipated. Phenomena that appeared inexplicable in former ages, are now satisfactorily explained; difficulties once deemed insurmountable have been overcome; discoveries have been recently made in the sciences and arts, of which the ancients could have no idea: and who, then, shall define the precise limits of human knowledge, or state the utmost progress which investigation can attain? Geology, indeed, from the nature of its objects, may seem less likely to be enriched by new discoveries, than most other sciences; yet who can tell to what a degree of maturity this infant science may at length arrive? A consciousness of our inability to unvail all the mysteries of nature, in this or in any other department of the creation, should indeed make us modest and humble in conducting our inquiries, but ought not to restrain us from pushing them to the furthest verge of human research. Close investigations of the works of Omnipotence, if pursued with a proper spirit, are so far from savouring of presumption,

that they are a part of the homage due to the Creator, whose infinite perfections are more and more illustrated and displayed, in proportion as his works are explored by the light of science.

Much has already been achieved by the labours of geologists. They have examined the character and form of large and interesting portions of the crust of the earth; particularly in different regions of Europe, and most of all in the British Isles: and from a review of existing facts, they have arrived at some important conclusions, now generally admitted. It is well ascertained, that the substances composing our globe are not thrown together in confusion, but are disposed in *strata*, or beds, of various thicknesses, or in crystallized masses, which, however irregular in form, display a regularity of structure; and that these beds or masses, which rise one above another, like successive courses of stone in a building, are not placed indiscriminately, but in a certain order; which, though it admits of considerable variations, is so far established, at least in the regions hitherto explored, that we may expect to find some kinds of rocks occupying the lowest stations, others in the highest, and others intermediate; while above the whole, there is usually an alluvial covering, which contains, along with vegetable soil, a promiscuous collection of detached fragments of rocks of all descriptions. It is also found, that the lowest rocks, among which the massive crystallized rocks of the granite family hold a distinguished place, contain no organic remains, that is to say, no remains of animals or vegetables; but that such remains occur in great abundance in some of the higher rocks; for which reason, as well as on account of their relative position, the former have been called *primitive* or *primary* rocks, and the latter *secondary;* while the beds interposed between them, containing very few organic remains, have obtained the name of *transition* rocks. The secondary strata are sometimes designated *flat* rocks.*

* There can be no propriety in retaining the German word *flœtz* as the title of such rocks, our English word *flat* conveying the same idea.

It is further known, that as there are vast masses of granite and other crystallized rocks, forming the basis on which other rocks are placed, and sometimes piercing into the beds above them in the form of veins; so there are also crystallized rocks, of a different structure, that frequently occur among secondary rocks; sometimes lying upon or among them in shapeless masses, sometimes intersecting them in veins or dykes, and sometimes lying over them, or interstratified with them, in beds of considerable extent and regularity. This kind of crystallized rock is known by the names *whinstone, basalt, trap,* &c.

In speaking of the relative position of rocks, it is necessary to remark, that those which are the lowest in geological situation, are often, in respect of some portions of them, the most elevated above the horizon. Granite, for instance, which is considered as the lowest rock yet discovered, frequently forms the summits of the highest mountains, the rocks usually super-imposed over it, being arranged in inclined planes on the sides of such mountains. Were all rocks horizontally stratified, the highest in geological position would also be uniformly the highest in horizontal altitude; but it is well known, that the strata lie most frequently in an inclined posture, *dipping*, as the term is, to one side; and as the upper beds, instead of being continued over the lower, are generally broken off, or discontinued, on that side which, owing to the dip, rises highest above the horizon, it is easy to see, that by this means, independent of other breaks and dislocations which frequently occur, the second bed in the series may, if sufficiently prolonged, rise higher than the first, and the third higher than the second; and the last, or lowest, beds or masses, rising from under the broken edges of the preceding strata, may be protruded to such a height as to overtop them all. Of this we cannot have a better illustration than in the section of the Yorkshire Coast, described in this volume; for here the beds, dipping toward

the south, are seen rising one after another from the level of the sea, and in like manner breaking off in succession, as we proceed northward; and the aluminous schistus, the last visible bed on the coast, is raised at Boulby to an elevation considerably greater than that of the chalk at Flamborough and Speeton, though the chalk is the highest rock in the district, in point of geological position. Thus, in a long series of strata, each bed is successively brought to the surface; and the lowest is as accessible as the highest.

This is one of those provident arrangements, by which the wisdom and goodness of the supreme Ruler are beautifully illustrated. Had the rocks been all placed horizontally, without any dip, and the upper beds been every where continued over the lower, we could have had no access to any of the lower beds, without piercing through the whole superincumbent strata; and this, in many instances, would have completely excluded us from various mineral products which are of immense benefit to mankind, and which, by the present disposition of the rocks, are placed within our reach. Besides, had the face of the globe been composed of one entire pile of level strata, without any break or dislocation, where would have been that beauty and glory with which it is now decked? Where would have been our hills and valleys, our mountains and plains, with all those charming landscapes, that richly diversified scenery, those grand and interesting features of nature, resulting from the inequalities of the earth's surface? And, supposing the sea to have remained, what would have become of our rivers and lakes, our fountains and streams; with the numerous blessings which they yield to man? The world, in that case, could not have been a fit habitation for the tenants that now possess it. Here, then, as in other provinces of his boundless dominions, the infinite Jehovah brings good out of evil, order and beauty out of seeming confusion and deformity, and the most precious benefits out of overthrow and

destruction. As his wisdom and power can levy a tribute of praise from the disorders of the moral world, the passions and crimes of men, which he over-rules for the purposes of his glory and grace; even so, in the material world, he can make the very ruin and wreck of nature to shew forth his praise.

It has been remarked, that the rocks which form the solid part of our globe, are not placed indiscriminately, but in a certain order. This, however, holds true, only in respect of general analogy; for, in descending to particulars, we find every region, and every district, to have its own series of rocks; nor have any two places, remote from each other, been yet discovered, in which the order of succession, or even the structure or composition of the beds, is exactly the same. And, though the order of the strata in some parts of Europe, appears to be subject to some general rules, it yet remains to be determined, how far these rules may extend to other quarters of the world. If Werner discovered a particular series of rocks in the Brocken mountain in Germany, it does not follow, that we shall find the same series in other mountains. If chalk constitute the uppermost bed in our district, and in several other parts of Europe, we cannot infer, that the same, or a similar bed, is, or has been, the highest, in Africa, Asia, or America. And, if granite hold the lowest place in the series, wherever the strata have yet been explored, we have no right to affirm, that other rocks still lower cannot be hereafter discovered. Let us not bewilder ourselves, nor mislead others, in assigning to nature imaginary laws of our own constructing, but advance in our inquiries after truth, by the sure path of patient investigation.

Perhaps there is no part of the world more interesting to a geologist than the British Isles; and no part has been more attentively surveyed. But, although much has been done, for ascertaining the character and succession of the British rocks, much remains to be

accomplished. Great attention has been paid to some districts, and almost every thing of importance relating to their geological features examined and made known; yet there are considerable portions of country, and these not uninteresting, of which no satisfactory description has hitherto been published; and not a few blanks remain to be filled up, before the survey of the United Kingdom can be viewed as complete.

To fill up a blank of this description, the present Work was undertaken. The strata of the Yorkshire Coast, comprising the Wolds, the Howardian hills, and the more elevated Eastern Moorlands and Cleveland hills, have not been described in any geological work, except in very general terms; and the authors, having prepared, for the HISTORY OF WHITBY AND THE VICINITY, a comprehensive view of the Geology of the district to which that work is limited, were induced, in compliance with the wishes of some respectable friends, to undertake a more full and accurate survey of the whole coast, from the Humber to the Tees. This survey they have at length completed, with no small labour; exploring the whole line of coast, and visiting every part of the interior likely to throw light on the objects of their research. Scarcely a hill or a valley, a cliff or a chasm, remains unexamined; scarcely an alum-work, a coal-pit, a quarry, or any other remarkable opening in the strata, has been left unvisited: so that, if the result should not come up to their own wishes, or the expectations of their friends, they cannot well charge themselves with want of diligence, patience, and perseverance. At the same time, they are far from supposing, that the work is free from mistakes, or that nothing more can be done for elucidating the geology of the district: on the contrary, their own experience has served to convince them, that a work of this nature is susceptible of progressive improvement; for as, in making this extended survey, they have been enabled to detect some mistakes in the sketch of the strata

contained in the History of Whitby and the Vicinity; so, in the prosecution of this undertaking, they have been able, in various instances, on repeating their visits to the same spots, to correct inaccuracies in their first observations, and every new journey has supplied them with additional illustrations of the objects of their pursuit. It is natural, therefore, to expect, that such as may trace their steps, will detect other errors into which they have fallen, and discover new facts which have escaped their notice; especially as, in a district so extensive, it is scarcely possible to give the same minute attention to every particular spot.

The district here delineated, is not distinguished by any of those grand and striking features, which mark the face of nature in some parts of the British Isles. It presents no stupendous mountains of granite, or porphyry, or mica-slate, or any other of the primary rocks; nor can it boast much of precious gems, or rich metallic ores. Yet its features are by no means uninteresting; and its mineral treasures, if not the most brilliant, are far from being despicable. In one kind of mineral riches, viz. organic remains, it may vie with any other portion of the globe, of equal extent. No where have the fossil relics of animals and vegetables been found in greater variety and abundance. Almost every stratum teems with substances formerly endowed with life and motion; and the fossil conchology of the district might of itself occupy a large volume. Hence, not only the mere geologist, but the student of natural history in its animated departments, may here find an employment adapted to his taste; in comparing the recent productions of nature, with those which have been imbedded in the bowels of the earth, and which are fitly regarded as the medals of nature's history.

To render this Work more perspicuous, and consequently more useful, it is arranged into *Three Parts*. The *First*, which is perhaps the most valuable to the geologist, contains a description of all the

strata of the coast, from the Humber to the Tees, in the order in which they occur; noticing the breaks, contortions, and other phenomena which they exhibit; and stating their connection with each other, and with the strata of the adjoining districts, as far as has been ascertained. In this part of the Survey, the authors have aimed at a simple detail of facts and appearances; avoiding, as much as possible, all those terms and phrases which involve any particular theory. The Map and Sections, accompanying this part of the work, have been constructed with care, and will, it is hoped, give the reader a clear idea of the extent and relative positions of the strata.

The *Second Part* enumerates and describes the petrifactions, and other organic remains, found in the different strata, or in the alluvial soil; arranging them into their various classes, and pointing out their several localities. This part, as may be inferred from a remark made above, might have been extended to a much greater length. The illustrative Engravings, which, in this department, are of more value than verbal descriptions, are fully as numerous as the proposed limits and price of the work would admit.

In the *Third Part* are thrown together some general observations on the facts exhibited in the two former parts; accompanied with hints and conjectures, designed to explain the phenomena presented, and to elucidate, in some degree, that interesting but arduous subject— the structure of the earth. This portion of the work will probably be deemed the least useful; yet as the hints here thrown out are chiefly suggested by existing phenomena, it is hoped that they may be serviceable to the studious inquirer. Where the views adopted by the authors militate against the favourite theory of any of their readers, they expect from the reader that candour and indulgence which he himself has a right to claim from others. On subjects involved in so many difficulties, mutual forbearance is indispensable.

On the whole, the authors flatter themselves, that their performance will not only prove acceptable to the lovers of science, but interesting unto others. To the manufacturer and the man of business, it may be of considerable service, to know the valuable mineral products of this part of England. The landed proprietor may derive much profit from an inquiry into the nature of the rocks of this district. Large sums have been thrown away in boring for coals, and other speculations, which might have been wholly saved to the adventurers, had they been properly acquainted with the strata. Above all, the admirers of the works of God, will here find matter calculated to awaken and cherish the best feelings of the soul, to call forth and keep alive those sentiments of devotion, humility, gratitude, and love, which, while they honour that infinite Being whose works are here examined and described, serve also to exalt our understandings, and improve our hearts. If the authors shall contribute in any degree to produce such effects, their highest object will be accomplished.

GEOLOGICAL SURVEY

OF THE YORKSHIRE COAST.

PART I.

DESCRIPTION OF THE STRATA.

THE whole of the rocks of this district, with the exception of a basaltic dyke that intersects a part of them, belong to the family of *flat rocks.* They lie in what is called a *conformable* series, that is, a series observing a kind of parallelism. Their general dip is towards the south, but at a great variety of angles, and with not a few contortions and irregularities; the strata frequently bending or undulating, in a curved form, and exhibiting in some places considerable breaks or dislocations.

In studying the characters and positions of these strata, at least where they form a part of the western barrier of the German Ocean, we have this important advantage, that they are all accessible, and open to inspection. Here the section of the strata is not, like the generality of sections, partly taken from observation, and partly filled up by fancy or conjecture: the whole is a real section, copied from nature; the steep sea-cliffs disclosing the whole series of beds in their proper order, together with their contortions and irregularities.

Perhaps it may appear most natural, in giving a description of the strata, to begin at the lowest visible bed, and proceed upwards: but as it is no small advantage, in every study, to set out with what is most plain and easy, and then advance to what is more difficult and obscure, it seems best, in the present instance, to commence with the uppermost beds in the series, and proceed downwards. Instead, therefore, of conducting the reader from the Tees to the Humber, we propose to reverse the order; and, commencing with the alluvium, which alone is visible in Holderness, advance northward to the chalk of Flamborough, and from thence along the coast to the great bed of aluminous schistus, and the rocks that are found near the banks of the Tees in the plain of Cleveland.

We begin then with

THE ALLUVIAL COVERING.

It may be deemed improper to rank the alluvium among the strata, as it is not, properly speaking, a part of the series, but a covering spread over the whole; not only lying over the chalk, in the southern part of the district, but lying over each of the rocks that successively rise up behind it, and filling up the intervals where they are interrupted, or sunk down. But, as it constitutes so large a portion of our sea-cliffs, as there is so much of our district where nothing else appears above the level of the sea, and as its materials and contents are not uninteresting, it ought not to pass unnoticed; especially as some of the beds of which it is composed, present in many places the appearance of stratification, and are considered by some as really stratified.

By inspecting the Map, and the Section of the Coast, the reader may perceive, that the whole southern part of our district is an alluvial tract, where no rock is to be seen. This tract comprises

all Holderness, with the environs of Hull and Beverley, and the rest of the flat country to the south of the Wolds; extending in length from the Spurn to Bridlington, a distance of about thirty-six miles, and in breadth, from the coast to the chalk hills on the west of Hull and Beverley, about sixteen miles. Besides this large alluvial tract, which is continued beyond the Humber, on the Lincolnshire coast, there are several other parts of the district where nothing but alluvium is accessible. This is the case with most of the extensive vale of Pickering, which opens towards Filey bay, where we find chiefly an alluvial cliff. In some parts of Robin Hood's bay, Sandsend bay, and Runswick bay, the cliffs are also alluvial; and the plain of Cleveland presents, in many places, a deep covering of the same description.

It is scarcely necessary to observe, that this alluvium, occurring where no rocks are discernible, is not materially different from that which covers the regular strata, where the latter make their appearance. We may remark, however, that the alluvial beds, as might be expected, are usually thinnest where the strata are most elevated; and in some parts of our hills the rocks rise to the very surface.

This part of the crust of our earth is called *alluvium*, because it appears to have been formed by the *washing away* of the other strata. It resembles the banks of rivers, formed by the accumulation of sand, gravel, mould, and other substances, brought down by the floods, and deposited in successive layers, wherever the waters overflow the lands adjacent to their wonted channels. Every river, except where its course is very rapid, or confined by rocks, has alluvial banks of this description, of more or less extent. The beds that cover the regular strata present the same kind of structure, though on a much larger scale, consisting of vegetable mould, sand, gravel, clay, marl, fragments of stone, with other substances, variously blended and arranged; sometimes disposed in beds or layers, and sometimes exhibiting a confused mixture.

In several parts of the coast, the alluvium is so regularly disposed in beds, that it almost deserves to be termed *stratified.* Instances of this kind appear in the cliffs between Whitby and Sandsend; but are more observable in the extensive alluvial cliffs of Holderness. Where this regular structure is discernible, the successive layers most commonly occur in the following order:

1. *Vegetable soil,* supporting the grassy mantle which clothes the surface. This valuable covering varies greatly in depth, being from two or three inches to a few feet.

2. *Marl,* or a mixture of marl and clay or mould. This bed is by no means regular, being in some places a few feet in thickness, in others not an inch, and in many places entirely wanting. The marl, in some instances, resembles pounded limestone, of a light blue colour, or blueish white. In a low part of the cliff, a little to the north of Bridlington Quay, occurs a fine white marl, containing shells and fragments of shells. Among these a small shell, resembling the *helix ericetorum,* which occurs recent on the Wolds, has been detected. A small bivalve shell is also found, which seems to be a species of *tellina.* All the shells are very thin and brittle. This white marl has the appearance of powdered chalk, mixed with a little clay. The marl, both here and in other parts of the coast, is often deeply penetrated by the roots of vegetables, from the soil above it.

3. *Sand and Gravel.* This bed is subject to as much irregularity as the former. In some parts it is several yards in thickness; in others, an inch or two; while in others it wholly disappears. In some instances, it forms only one bed; in others, two or more successive layers, alternating with marl, or clay; especially the latter. In many places, the sand is found pure, without any gravel; in other spots, the gravel occurs, with little or no sand. Almost all the springs that issue from the cliffs have their sources in the beds of sand and gravel;

and where the discharge is copious, the sand must needs be washed away, and the gravel alone remain. Some of the sand in the cliffs near Whitby is magnetic, particularly a brown sand found at Upgang.

4. *A brown, coarse clay.* This clay has an earthy aspect, and is not very tenacious, being frequently mixed with sand and marl. It contains numerous pebbles, nodules, and fragments of stone of all descriptions. This bed forms a large portion of the alluvial cliffs, being often several yards in thickness. It is frequently met with immediately below the vegetable soil; the marl, and the sand and gravel, in such places, being either blended with it, imbedded in it, or altogether lost. Sand beds often occur in this clay at a great depth below the surface; as may be seen between Whitby and Sandsend, where a large bed of sand and gravel is found about half-way down the cliff.

5. *A darker, ash-coloured clay;* commonly more compact than the brown clay, and less mixed with marl or sand; though containing the same abundance of nodules and fragments of stone. This bed, like the former, is often of vast thickness. Sand beds sometimes alternate with this clay, as well as with the brown clay. A bed of brown sand is found at Upgang at the very base of the cliffs.

These two kinds of clay frequently pass into one another, and at the place of their junction are found clouded and intermixed, instead of presenting a distinct line of separation.

6. *A blueish, or blackish, tenacious clay.* This bed, which is also in some places of considerable thickness, forms the lowest visible portion of the cliffs, in several parts of Holderness, and in other alluvial cliffs along the coast. It occurs at the bottom of the cliff between Upgang and Sandsend; where its slippery, treacherous surface, laid bare by the washing away of the upper beds, and moistened by every returning tide, often makes the unwary passenger fall flat upon the beach.

As the brown clay passes into the ash-coloured, so the latter passes into the blue clay, which often occurs in patches, rather than in a distinct bed. Indeed, all the three kinds of clay are often seen blended together in one mass: but we generally find the brown clay uppermost, the ash-coloured in the middle, and the blue tenacious clay in the lowest place.

These beds, or divisions, of the alluvial covering, are perhaps as regular as some of the beds of clay and gravel lying over the chalk in the south of England, which are regarded by many as part of the regular strata: but since all the beds now enumerated contain more or less of the fragments of rocks of almost all descriptions, and since we find nearly the same succession of beds over the sandstone near Whitby, as are over the chalk in Holderness, it seems most proper to consider the whole as an alluvial covering. Perhaps it may be fairly questioned, whether the beds of sand and gravel at Woolwich and other parts in the south, which have been described as properly stratified, be any thing more than a part of the alluvium; and the same remark may very possibly apply to those gravel beds in France and elsewhere, which have been dignified with the title of *fresh-water formations.*

At the same time, if any shall affirm, that the sand beds in what we have described as alluvium, might in other circumstances have become sandstone, that the marl might have formed limestone, and the clay have become shale, we will not dispute the matter with them. In fact, there are spots where we find marl so indurated as to approach very near the state of limestone; the clays, particularly the darker coloured clays, almost in the state of shale; and the beds of sand and gravel actually hardened into solid rock. An instance of this last kind may be seen between Whitby and the Lector Nab, where some springs that issue from the middle of the cliff, and deposit lime and oxide of iron, have not only formed calcareous

incrustations of moss immediately below their source, but have consolidated into a kind of *breccia*, or conglomerate, a large portion of the bed of sand and gravel through which they ooze. Masses of this newly formed stone fall down occasionally on the beach.

It is proper also to notice, that these alluvial strata, if we may so term them, have in some instances undergone the same kind of breaks and contortions as are seen in the rocky strata. A curious illustration of this remark was observed by the authors in a part of the cliff near Skipsey. The brown clay and the sand imbedded in it are there contorted and twisted in the most singular forms; and while the outline of the sand bed is deranged and bent in all directions, the bed itself, being composed of sand of two distinct colours, brown and yellowish white, arranged in very thin layers, exhibits a beautiful collection of undulating and twisted lines. A specimen of these is represented in Plate I. Fig. 1. There is a strong resemblance between these contorted layers of sand, and the contortions observed by Dr. Mac Culloch in the primary strata of Glen Tilt.* Another instance no less curious is delineated in Plate I. Fig. 2. It represents a portion of the cliff near Cowden in Holderness. The brown clay *aaa* is broken and contorted; the sand and gravel bed *bcd*, which is four feet thick at *b*, fills up the sinuosities in the clay, particularly the large gap *c;* while the marl bed *ee*, about two feet thick, and the vegetable mould at the surface *ff*, about a foot thick, are not at all affected by the dislocations underneath them. It seems as if the surface of the clay bed, before the deposition of the beds above it, had, by the action of currents, or some other causes, been worn into hollows or sinuosities, which the sand and gravel, subsequently spread over it, completely filled up, so as to present a level surface on which the marl was afterwards deposited.

* See Geological Transactions Vol. III. Pl. 15, 16, 17, &c.

The thickness of the alluvial beds, as might be expected, is greatly diversified. The most lofty of the alluvial cliffs on the coast are from 120 to 150 feet high, or perhaps somewhat more. The cliffs near Upgang, and those opposite Grimston and Aldborough in Holderness, are among the highest. The alluvium at Aldborough, however, must be vastly thicker than at Upgang; for at the latter place the rock is found near the base of the cliff, and may be seen at low water stretching into the sea; whereas at the former, the rock being at an unknown depth, there is probably as great a thickness of alluvium below the level of the sea, as we find above it.

Though the alluvial beds are in general pretty level, especially where they fill up the vacancies or breaks in the regular strata; yet we often see them assuming, in some degree, the shape of the strata which they cover, and having the same inclination or dip. Hence, as the chalk of Flamborough, where it sinks beneath the horizon, dips towards the Humber, the alluvial covering of Holderness, though broken in many places by the openings of the rivers and meres, preserves a general slope in the same direction; and at its extremity, the Spurn, becomes a low point, only a few feet raised above the level of the ocean.*

To enumerate the different kinds of rock occurring in the alluvium, in rounded nodules or angular fragments, and the different kinds of pebbles of which the gravel is composed, would be to go through nearly the whole nomenclature of the rocks known to exist. It is easy to meet with fragments of granite, gneiss, porphyry, mica-slate, with almost every variety of the primary and transition rocks. Blocks of beautiful porphyry, with large flesh-coloured crystals of felspar, occur in considerable quantity on the Stainton Dale shore,

* Hence we may observe, that those antiquaries who consider the Spurn as Ptolemy's *Ocellum promontorium,* and derive that name from the British word UCHEL—*high,* must at least be mistaken in their etymology.

among a vast variety of stones washed down from the alluvial part of the cliffs. Masses of the encrinite limestone, mountain limestone, white limestone; with various kinds of basalt, and even lava, have been disengaged from the alluvium near Whitby. Agates, carnelians, amethysts, calcedonies, and a great variety of jaspers and jasper-agates, with various other precious stones, are found on the beach all along the coast; and are sometimes picked up on the moors, where the surface is laid bare.*

Yet, while the alluvium presents a promiscuous assemblage of all kinds of rocky fragments and nodules, it must be remarked, that a large proportion of them belong to the rocks of this district; such as chalk, flint, blue limestone, grey limestone, sandstone in all its varieties, aluminous schistus, coal, &c. Some also belong to adjoining districts. In the Whitby cliffs we find masses of magnesian limestone, such as occurs at Sunderland, and in other parts of the county of Durham: and in the Holderness cliffs we often perceive fragments of coal, of the same kind that is found in the neighbourhood of Leeds.

One thing more remains to be noticed, respecting these stones imbedded in the alluvium; and that is, that the fragments which abound most in any particular quarter of the district, generally belong to the rocks of that quarter. Thus, though we find aluminous schistus in the Holderness alluvium, and chalk and flint in the Whitby alluvium; yet the schistus is much more abundant in the latter, and the chalk in the former. In some parts of the alluvial cliffs between Whitby and Sandsend, fragments of schistus occur in great numbers, and serve to deepen the colour of the lower beds of clay, in which they are most abundant. On the other hand, the

* A variety of the minerals belonging to the alluvial beds, though not described as such, are enumerated in the Scarborough Catalogue of Fossils.

Holderness cliffs are speckled with numerous fragments of chalk; and the white colour obviously increases as we approach to Flamborough, especially as the marl becomes cretaceous in the neighbourhood of the chalk. In like manner, as the gravel near Whitby abounds with pieces of sandstone, the gravel near Flamborough abounds with fragments of chalk and of flint.

It has been observed, that beds of sand and gravel sometimes alternate with the lower beds of clay, as well as the higher, and may be seen near Whitby at the foot of the alluvial cliffs, very little above the solid rock. Examples of the same kind occur in the alluvium that covers the chalk; particularly at Bridlington Quay, where a bed of cretaceous flinty gravel, of considerable thickness, is found immediately over the chalk. This bed, like many other gravel beds, is a receptacle for waters, and the parent of copious springs; some of which are seen issuing from the cliff to the north of Bridlington Quay, just before we arrive at the chalk rocks.

The most remarkable spring proceeding from this gravel bed, is the ebbing and flowing spring of Bridlington Quay. This most copious fountain was discovered in 1811, when, with a view to the improvement of the harbour, the alluvium which forms its bed was bored through. The alluvium was found to consist of a bed of compact clay, 28 feet thick, and a bed of cretaceous flinty gravel, 15 feet thick; beneath which was the solid chalk. At first there was no indication of a spring, but after the aperture was made, a plentiful supply of excellent fresh water rose in it with the rise of the tide, and not only filled the bore completely, but flowed over in a powerful stream, being projected some inches above the top of the bore. It boiled up with most impetuosity at high water, and gradually fell as the tide retired. The same phenomenon has continued ever since; and the inhabitants, to secure the benefits of this valuable spring, have fixed a tube in the bore, to receive the rising column of water,

and constructed a reservoir, &c. for the use of the town and shipping. There is no discharge from the tube, till the tide has risen to such a height as to be only about four feet lower than its orifice; and when the sea has again subsided to the same level, the stream ceases to flow till the return of the next tide; the discharge continuing four or five hours each flood. In high tides, the stream, as may be expected, flows longer than usual: and after great rains the discharge is both more copious, and more prolonged; being known to commence when the level of the tide is about eight feet below the mouth of the tube. When there is a heavy sea on the coast, an undulation is observable in the discharge of the water.

The most easy and obvious way of accounting for these facts, is by supposing, that this spring has an outlet towards the sea, probably beneath low water mark; which outlet is open at low water, so far as to permit the spring to empty itself into the sea, but is obstructed or choaked up by the flood tide; so that the fresh water, accumulating in its gravelly receptacle, bursts forth at the new opening which has been made for it; and continues to flow from thence, till the falling of the tide permits it to resume its original passage. As the obstruction of this passage will gradually increase as the tide rises, and diminish as it falls, and be greatest at high water; being according to the weight of the sea water over the outlet, and the quantity of that water pressing into that outlet, and forcing back, or stemming, the current of the fresh water; the phenomena observed at the orifice of the tube are just such as, on that supposition, might be expected. The undulations occasioned by a storm, may be traced to the irregularity of the pressure then felt at the sea outlet, the heavy waves forcing the salt water into it by sudden jerks, and giving a corresponding impulse to the fresh water then propelled before it. It is no less natural to expect, after heavy rains, a larger accumulation of fresh water, and consequently a more copious discharge at the spring;

especially as the thickness of the bed of gravel at that spot, and the slope which it must have from the chalk hills towards the sea, corresponding with the dip of the strata, must give great facility to that accumulation. Nor is it less difficult to conceive, why the water at the spring is never brackish; for though the force, or weight, of the fresh water current, is insufficient to clear its passage into the ocean, when opposed by the weight of the rising tide, it may be fully adequate to stem the opposing current of salt water, so as never to allow it to reach the spot where the tube is inserted; especially if, as is probable, the sea outlet be at a great distance, and the passage to it be intricate, winding, and parted into several channels. The same considerations, viewed in connection with the comparative lightness of fresh water, may enable us to understand, why the water in the spring rises so much higher than the level of the tide.

This ebbing and flowing spring is not the only phenomenon of the kind. At the mouth of the river Loe in Cornwall, there is a fresh water lake which communicates with the sea by a subterraneous passage. The water rises and falls with the tide, yet is always fresh. An instance of the same kind has been observed in New Holland.*

Strange as this phenomenon may appear, it is not more strange than some of the notions advanced to explain it. Since the discovery of the spring, various writers have published, in the literary periodical works, descriptions of the facts observed, accompanied with theories proposed to account for them.† Some of these explanations nearly coincide with the solution given above. Others proceed on suppositions that are wild and improbable. One hypothesis, in particular, is so extravagant, and rests on assumptions so inconsistent with facts, that it may be proper to notice it, in order to correct the mistakes connected with it.

* See Geological Transactions, Vol. I. p. 140, 141.

† Philosoph. Trans. for 1815, Pt. I. Philos. Journal XLV. p. 66 & 432. XLIX. p. 230. L. p. 81—83, 200—203, 267, 268. Repertory of Arts Vol. XXX. p. 342, &c.

Dr. Storer, in the close of his account of this spring, communicated to the Royal Society, had suggested, that this ebbing and flowing fountain might have some connection with the intermitting springs called the *Gipsies;* an idea which he could not have entertained, had he been properly acquainted with the history and situation of these springs. A writer in the Philosophical Journal, evidently less acquainted with the country, catches at this unfounded notion, and assuming that the stratum of clay and substratum of cretaceous gravel, found at Bridlington harbour, extend over all Holderness, nay over the Wolds too, beyond the Gipsies, alleges that the latter "will be found mere perforations of the substratum of clay; and one and all of them at some seasons, although distant from the sea, to be more or less ebbing and flowing springs;" that the pressure of the tide upon the elastic bed of clay occasions the flowing of the springs, and the removal of that pressure the ebbing of them; nay, "that the whole bed (of clay), extending from Flamborough Head to Spurn Point, will be found to rise and fall with the ebbing and flowing of *every* tide"!*

These assertions are not only in direct opposition to facts, but, as far as regards the last of them, so contrary to the nature of things, that it is difficult to believe, that a writer who has produced so many judicious papers on other subjects, could be serious in advancing them. Alas! poor Holderness, hard is thy fate! Other lands may be visited with earthquakes once in half a century; but thou art doomed to suffer an earthquake twice a day;—an earthquake which heaves thy bowels, and makes thee vomit out thy waters, even at the distance of many miles from thy coast! Tough indeed must

* Philos. Journal, L. p. 81, 82. Another writer in the same volume, p. 267, 268, gravely remarks, that this supposed daily earthquake does not extend to Hull. He had resided there several months; and could attest that during all that period the town stood still. Had he been stationed on the Holderness coast, he might have borne testimony, that the land there is also *terra firma.*

be thy clayey tunic, that has so long held together, under these daily convulsions. Well may historians report, that part of thy shore has been lost, and that some of thy towns have sunk in the ocean; for it is marvellous that such reiterated shocks have suffered even a fragment of thee to exist.

The author of this hypothesis might almost as well have accounted for these phenomena, by adopting one of the fables of the ancients, and applying it to this district. He might have alleged, that a mighty giant, another Enceladus or Typhoeus, such an one as could set Ossa upon Pelion, or Rosebury Topping upon Black Hambleton, lies buried alive under Holderness and the Wolds, with the Wolds on his head, and the Spurn on his feet (and *spurn* seems to have a natural connection with *feet);* and that this son of Titan, whenever old Ocean lashes his sides, begins to puff and blow, trembles in every limb, sweats at every pore, and vomits forth,— not smoke, and flames, and liquefied stones, like his brother who groans under the weight of mount Ætna,— but streams of pure water!

But, to be serious. There is no good ground for supposing that the clays of the Holderness coast form a continuous covering; much less for imagining, that a stratum of gravel uniformly runs between the clay and the chalk. In the cliffs near Whitby, we find the clays in some places resting on the solid rock, while in others a bed of gravel appears to intervene: and it is highly probable, that the same irregularities prevail in Holderness. It is well known, that the scarcity of water on the Wolds does not arise, as that writer fancies, from their being coated with a stratum of clay impervious to water, with a substratum of gravel which steals all the water from the surface; for no such stratum and substratum exist there, except on part of the southern skirts of the Wolds, where there is little or no scarcity of water; but it results from the absorbent quality and numerous fissures of the chalk, which rises almost to the surface. Much of the rain

that falls on the Wolds, like that which falls on the limestone hills of the vale of Pickering, is speedily absorbed, and collecting in fissures of the rock, is conveyed by these internal channels, as well as by channels on its surface, to the lower parts of the hills, where copious springs burst forth from the openings of such fissures. A large stream of this description has found a vent for itself at Springhead near Hull; and the copious flow of water at Bridlington Quay may be owing to the bursting forth of a stream from the interior of the chalk, more than to the collection of water on its surface. Perhaps too, the beds of gravel, lying over the chalk at those springs, might be formed, or greatly increased, by the agency of such subterraneous streams; as the gravel there consists chiefly of fragments of chalk and flint, which these streams might carry down, from the beds through which they force their passage.

The Gipsies, which rise near Wold-Newton, about ten miles north-west from Bridlington Quay, are intermitting springs of a very different description from the spring at the latter place. They never flow but after great rains; and appear to be occasioned by the superabundant waters of a subterraneous stream of the kind now described. That stream for the most part finds its way under ground; but when its waters are so swoln, that they cannot get vent by their secret channel, they are forced to rise to the surface by such crevices as they can find: and as the bursting out of this new opening, together with the accumulation of mud, sand, and gravel, occasioned by the excess of the waters, may partially choak up the usual passage, the springs at the surface may thus be made to flow longer, and more copiously, than might otherwise be expected.* These springs, though they always rise near the same spot, are not confined to two or three

* Our esteemed friend Thomas Hinderwell, Esq. considers the Gipsies as most probably the re-appearance of a stream of water running eastward, which is absorbed a few miles west of Wold-Newton. Hist. of Scarborough, 2nd. Edit. p. 280.

large orifices, but appear to ascend from a multitude of small crevices or openings, often trickling through the grass where the ground is unbroken, and leaving scarcely a vestige of the places from whence they issued, when the period of their flowing is over. As the rise of the Gipsies depends on the quantity of moisture imbibed, they usually rise in the most rainy season of the year; that is, in winter; or in the beginning of spring, when the snow is melting. Sometimes they flow for two or three months together, and the discharge has been known to be so copious, that the current filled a drain six feet wide, and three feet deep. In other seasons they never rise at all, and intervals of three or four years occasionally intervene between one overflowing and another.

It is worthy of notice, that these intermitting springs were known so early as the reign of king Stephen, when they presented the same phenomena as they do now, and even passed by the same name. William of Newburgh, in recording the events of that monarch's reign, makes mention of the Gipsies; which he describes as rising at intervals of some years, and forming, when they did rise, a considerable torrent. And he observes, that it was a good omen when they were dry, for their flowing was deemed a sure prognostication of an approaching famine. We are not aware, that their rise is considered as equally ominous now. Excess of drought is more likely to produce famine on the Wolds, than excess of wetness; yet as a dry summer may be expected to succeed a very rainy winter, the breaking out of the Gipsies may perhaps, in this light, still portend an unfavourable season.*

* William of Newburgh was born near the Gipsies. He gives these springs the name *Vipse;* but *G* and *V* or *W* were then frequently interchanged. *Vasconia* was the same with *Gasconia, Willielmus* the same as *Gulielmus;* and *Vipse* may therefore be said to be the same name as *Gipse.*

It may be gratifying to some of our readers to give that Historian's account of these springs in his own words. He notices them in relating a prodigy, said to have been seen at a

The celebrated Scarborough springs, whose medicinal virtues began to be noticed about two hundred years ago, issue from the lower part of a high alluvial cliff; consisting chiefly of brown clay, with sand and gravel. The clay contains vast quantities of imbedded nodules and fragments of stone of all descriptions, among which aluminous schistus and ironstone appear to predominate. The springs, which are two in number, percolate through this clay, but probably have their true sources in the gravel, of which an immense mass, containing numerous fragments of rocks, is seen in an adjacent part of the cliff. The falling down of the brown clay has in a great measure displaced or covered the gravel beds, at the spot where the springs appear, and thus concealed their real sources. In the year 1737, a portion of the cliff, containing near an acre of pasture ground, with the cattle grazing upon it, sunk perpendicularly several yards; on which occasion, it would seem, the thick bed of brown clay forced from beneath it the sand and gravel beds, which were consequently protruded outwards at the bottom of the cliff, forming a ridge above 100 yards long, 26 broad, and 6 or 7 high. The staith which then secured the wells with the buildings belonging to them, coming within the limits of this ridge, rose with it in one entire mass 12 feet above its former position, and at the same time was protruded forward about 20 yards. The springs, as might be expected, were instantly

tumulus not far from the springs. His words are as follows: In provincia quoque Deirorum, haud procul a loco nativitatis meæ, res mirabilis contigit, quam a puero cognovi. Est vicus aliquot a mari Orientali miliariis distans, juxta quem famosæ illæ aquæ quas vulgo Vipse vocant, numerosa scaturigine e terra prosiliunt, non quidem jugiter, sed annis interpositis, et facto torrente non modico, per loca humiliora in mare labuntur: quæ quidem cum siccantur, signum bonum est; nam earum fluxus futuræ famis incommodum non fallaciter portendere dicitur. G. Neubrigen. l. I. c. 28. Perhaps Vipse ought to be read Vipsæ, with the proper Latin termination. The distinction between these two terminations is seldom observed in ancient manuscripts.

Plot, in his History of Oxfordshire, p. 30, mentions some intermitting springs, which are said, like the Gipsies, to be always dry in fertile years; their flowing being considered as the harbinger of dearth.

choaked up; but by diligent search were again recovered, rising, most probably, from under the mass of clay that had overwhelmed them, or percolating through fissures or crevices in its substance. The virtues of these waters are no doubt owing to the nature of the minerals through which they pass. Their principal ingredient is sulphate of magnesia, which is most abundant in the south well. They also contain muriate of magnesia, carbonate of lime, sulphate of lime, with a small portion of carbonate of iron, and of muriate of natron.*

Before we take our leave of the alluvial covering, it will be proper to advert to those remains of peat bogs or morasses, which are found under some of the alluvial beds, and which in many instances occur below the level of the sea at high water, and are hence described as the remains of submarine forests.

An extensive morass of this description exists on the banks of the Humber in the vicinity of Hull, where it forms a sort of stratum about three feet thick, consisting of moor earth, decayed trees, and other vegetable substances. Similar remains have been found at Withernsea, Hornsea, and some other parts of the Holderness coast; and it is well known, that they have also been observed in great abundance on the southern banks of the Humber, and on a great part of the shores of Lincolnshire. The same phenomenon has been met with on the banks of the Esk in Whitby harbour, particularly in digging for the formation of docks; and may be seen also on the Durham shore, between Hartlepool and Seaton.

In these bogs or morasses are found immense quantities of trees, of various sizes, with branches, leaves, roots, &c. The trees are of such kinds as are known to be natives of this country, as oak, ash, fir, hazel, holly, beech, willow, &c. The fruits of some of them,

* See Hinderwell's Hist. of Scarborough, 2nd Edit. p. 206.

particularly hazel-nuts, acorns, and the cones of the fir, are often met with in great abundance. Immense quantities of leaves are found matted together; and these leaves may frequently be separated and obtained entire, by dipping lumps of the decayed masses in water, and dissolving or breaking them, when the leaves may be seen on examining the fresh fractures. The leaves are usually intermixed with decayed grass, and other vegetable remains. On examining the contents of the bog at Hartlepool, the authors also discerned among the leaves the remains of insects, particularly the wings of small beetles. The trees are generally much decayed; though many of the oaks are in a good state of preservation. The bark of the hazel and the birch often appears remarkably fresh, while the wood is completely rotten.

It has been supposed, that an entire stratum of this kind of bog, three or four feet thick, passes under Holderness; that the one edge of this stratum may be seen on the banks of the Humber and of Hull river, while the other edge may be traced all along the coast from the Spurn to Bridlington; and that it may be found in any part of the interior of Holderness, by boring to the same depth.* But these ideas are neither consistent with facts, nor agreeable to the nature and arrangement of the alluvial beds. It is not correct to say, that such remains may be found at low water all along the Holderness coast; for they are found only in certain spots, the greater part of the coast being destitute of them. Did a continued stratum of this kind really exist, we ought not to find it at one uniform level, but rising or falling with the curvature or dip of the other alluvial beds. The truth is, though the morass found at Hull probably extends through the whole of the flat ground in that vicinity, whether near the sea or not, the remains of that description observed on the Hol-

* See Dr. Alderson's Paper on this subject in the Philosophical Journal for October, 1799.

derness coast are not the continuation of the Hull bed, but mere patches, occurring here and there. These patches have not only no connection with the Hull morass, but no connection with one another. The largest of them occur where the cliff is very low, or where there can scarcely be said to be any cliff at all; and those small patches which occur where the cliff is lofty, as between Sandley Mere and Hornsea, are not found at the foot of the cliff, or within reach of the tide, but always a few feet below the surface. Fragments of this kind of bog may indeed be found occasionally at the base of the highest cliffs; but this is only where they have fallen down from their proper bed.

An instance of this was observed by the authors nearly opposite a place called Grimston Garth, not far from Aldborough. There, at the foot of a cliff about 100 feet high, they met with masses of bog earth, with portions of trees, branches, roots, and other vegetab e substances. Some parts of these masses, in a half dried state, might be split into thin flexible pieces, forming a kind of elastic bitumen. On examining the cliff, it was found, that these masses had been washed down by the rains from a bed of peat which lies seven or eight feet below the surface, about a foot in thickness, and extending horizontally along the face of the cliff a number of yards. The bed does not appear to reach a great way inward; but it may have extended outward to a considerable distance, when the sea had not encroached so far on the land; and probably the broadest and deepest part of it has long ago been washed away. This peat bog abounds with decayed branches of hazel, and other shrubs; and with the leaves and roots of vegetables, particularly reeds or rushes, the seeds of which are also very discernible. Over the peat lies a bed of light coloured marl, of a fine texture. In some places it is tinged with a beautiful light blue, in small specks, exactly the colour of those minute insects that are found in myriads floating on the surface of

stagnant ponds. The authors also found here an imperfect valve of a fresh water muscle. The marl in some parts is so indurated as to have nearly acquired the hardness of limestone; and, in like manner, a few portions of the peat approach to the state of coal. Over these beds is the highest part of the alluvium, consisting of coarse clay or clayey marl, with vegetable soil.

Similar patches are found in the cliffs between Cowden and Hornsea, at a great elevation above the sea, and only a few feet below the surface. In one of these exposed bogs, near Cowden, an efflorescence of sulphate of iron was observed in several spots, on the face of the cliff. Patches of peat bog may also be observed between Hornsea and Bridlington; but the most remarkable instance occurs opposite Skipsea. Here a large morass, several feet in thickness, is exposed to the sea, containing as usual decayed trees, and other vegetable remains. The alluvial covering over it is in general very slight, and in some parts the peat reaches the surface. This morass cannot be called submarine, for though the sea washes the lower part of it at high water, it does not cover the upper part. Here, as in the cliff at Grimston Garth, the authors discovered the shells of a fresh water muscle, apparently the *mya pictorum*.

From these facts, compared with others which are yet to be stated, we arrive at the conclusion, that these supposed remains of submarine forests are only the bottoms of fresh water lakes, or meres, which the sea has broken into, and drained. Wherever the country has abounded with wood, and this was once the case with a great part of Britain, the bottoms of meres or marshes contain vast quantities of these decayed trees and vegetable substances. They are found in the bottom of Hornsea mere, wherever it has been dug into; and were the sea to break through the barriers of that mere, the same kind of peat bog would be exposed there as we see in the spots already mentioned: nay, we should find over the peat a stratum of

marl, as in the Grimston cliff, for in the bottom of Hornsea mere, above the vegetable remains, there is a quantity of fine light powder, which if indurated would form a marl of the very same nature. Dr. Plot, in his History of Oxfordshire (p. 160, 161, 53, 57), mentions the discovery of large trees, with other vegetable remains, in the bottom of ponds; particularly at a place called Blund's Court; where also there was found, over the decayed vegetables, a bed of fine light coloured marl, which, like that in the cliff near Grimston, contained "a blueish substance, much of the consistence of flower of sulphur, and not much unlike to the finest blue starch." This substance, which, as was hinted above, we conceive to be the remains of minute blue insects, he names *cæruleum nativum*, or *native blue;* but he very correctly states, that it is so intermixed with the marl, "that no quantities can be got for the painter's use." In the bottom of the same pond, there was found a stag's head with the antlers, together with two Roman urns.

It would be easy to multiply instances of the same kind, observed in other parts of Britain, and in the north of Ireland:* but our own district and its vicinity will supply a sufficient number of facts, to illustrate and confirm the opinion which we have advanced. When the mere at Seamer in Cleveland was drained a few years ago, the bottom of it was found to be a peat bog, containing numbers of trees; and the skulls and antlers of deers, with the horns and bones of a large species of ox, were also discovered. Similar remains, both vegetable and animal, have been found at Malton, near the bed of the Derwent. At a former period, the course of that river below Malton appears to have been greatly obstructed, and its waters collecting in the vale of Pickering, and towards Malton, formed extensive marshes, the bottoms of which now exist in the form of peat bogs. Hence we

* See Philosoph. Transactions, V. XXII. No. 275, p. 980, &c. Geological Transactions, V. III. p. 380; IV. p. 443.

find in Domesday a number of places in that quarter taking their name from *meres*, now unknown.* Even at present, the waters of the Derwent, with those of the Rye and other tributary streams, frequently overflow the low grounds of the same valley during part of the winter; and they did so to a greater extent, before the formation of the *New Cut* from the Derwent at Everley to Scalby beck, which, like a safety valve, serves to carry off the superfluous waters. In like manner, the peat bog on the banks of the Esk above Whitby bridge, which is probably continued in the flat ground at Ruswarp, may have been formed at some distant era, when the mouth of the river was obstructed by rocks or banks, not now existing, which completely excluded the tide, and made the waters of the river to accumulate above it, so as to form a small lake on the site of the present harbour.

The morass at Hartlepool is evidently a continuation of the *slake*, the bottom of which contains large trees and other vegetable remains, with the antlers of deers and other animal substances.† The morass now exposed to the waves has been the bottom of another slake, or of another division of the same slake; from whence, at a remote period, the sea has been excluded by a barrier, now demolished, which permitted the accumulation of fresh water on this spot, and the consequent formation of a morass.

That the morasses on the Holderness shore have been the bottoms of meres, may be inferred even from the names of the places where they occur. Sandley-*mere*, into which the sea appears to have broken at no very distant period, speaks for itself; and the names Skip*sea*, Withern*sea*, and Kiln*sea*, indicate that a *mere* has existed at each of these places, as there still is at Horn*sea*. The termination *sea* (or *sey*, as it is also spelt,) in these names, is not our modern word denoting

* As Odulfes*mare*, Chiluesm*ares*, Aschiles*mares*, Maxudes*mares*, Chigoges*mers*. See Bawdwen's Domesday, p. 11.

† Sir Cuthbert Sharp's History of Hartlepool, p. 3.

the *ocean*, but is nearly synonymous with *mere*.* Both terms are united in the name *Sea-mer*, that belongs to two places in our district, neither of which borders on the sea. Seamer in Cleveland could not be so named from its maritime situation, being more than twelve miles from the shore.

That a considerable *mere* has existed at Skipsea, appears from what has been said of the remains that are found there: and the idea is corroborated by the well known fact, that a large tract of land, on which stood Hyde, Hartburn, and perhaps other towns or villages, has been swept away from that part of the coast by the violence of the ocean. That tract of land, forming the barrier of Skipsea mere, and probably of another mere near Barmston, being destroyed, the sea broke into these meres, and their boggy substratum became exposed to the waves.

Hornsea formerly belonged to a chain of meres, some of which have been drained, or otherwise exhausted, on the land side, while one at least has been destroyed by the sea. The decayed vegetable remains existing on the shore opposite to Hornsea, point out the site of a mere in that direction; and on the contrary side were the meres of Wassand and Seaton. The privilege of fishing in the meres of Hornsea, Wassand, and Seaton, as also in that of Agnes Burton, was given to the monks of St. Mary's abbey at York.† The name of the last place, Agnes, was formerly written *Agnese* or *Agnesea;* having the same termination as Hornsea and Skipsea, and for the same reason,— the existence of a mere at the place which it designated. We may remark also, that *Sea*ton, like *Sea*mer, did not derive its name from the *ocean*, but from the mere or lake on which it stood.

* The word *sjo* in the Scandinavian languages signifies a *lake* as well as the *sea;* and the Saxon word ȝæ might be used in the same way: yet the ancient names of places in our district seem to be more Danish than Saxon. See Hist. of Whitby, Vol. I. p. 82, 83, 84. Vol. II. p. 897.

† Drake's Eboracum, p. 593, 606.

The vestiges of a mere at Withernsea are less obvious than at Skipsea; yet the recess in the shore at that place seems to mark the spot which it occupied. The sea, however, has not only broken into that mere, but encroached on the land beyond it; the boggy remains being found, not in the face of the cliff, nor at the foot of it, but at a considerable distance outward. Some fields on the shore, with part of the church of Owthorn, have been destroyed at no very remote period. On looking into Domesday, we find that another mere formerly existed in this quarter, called Redmere or Rotmere, with a town called Redewick. It is possible that *Red*mere might be so named, in contradistinction to *Wyt*hornsey or *White*-Hornsey, one of the ancient names of Withernsea; though it is more likely that *Red* or *Rede*, in the former name, corresponds with the modern word *reed*, and that Redmere had its name from the *reeds* which grew in it. Levetotholm, and Canutesholm, also mentioned in Domesday, appear to have been low lands formerly opposite to Holmpton, or Holmtown, which is likewise named in that record. It contains the names of various other places in that quarter, as Totele, or *Toteley*, Cletun, perhaps *Claytown*, Andreby, &c.; no vestige of which is known to remain.

The depredations of the German ocean at Kilnsea and towards the Spurn point have been still more considerable; and it is probable that more than one mere may have perished there. Ravenser, or Ravenspur, with the latter part of which word the name *Spurn* seems to be connected, has long ago been lost, with a number of other places in that vicinity, belonging to Birstal priory; nay, the very site of the priory itself has been totally swept away.

The marshes along the banks of the Humber, and on those of Hull river, have been of far greater extent than those of the Holderness shore. It is stated in Dr. Alderson's paper, above referred to, as a proof of the existence of a stratum of peat bog under the whole

of Holderness, that the boggy earth was found in sinking a well a mile from the sea; but the same circumstance might occur many miles from the sea; for the woody marshes, which produced the peat bogs, not only existed in the neighbourhood of Hull, and on the banks of the Humber, but extended northward almost to the vicinity of Driffield. We not only read of marshes at Saltagh, Kayingham, Sutton, and Marfleet (anciently *Mereflete*); but find them also at Weel, Beverley, Leckonfield, all around Melsa abbey, and even as far as Watton priory. Melsa is described as in the midst of woods, waters, and marshes.* Beverley was similarly situated; for its Saxon name indicated that it stood in the woods of Deira;† and we find from Domesday, that its waters were abundant, for there was "a fishery of seven thousand eels" here. At Cottingham were five fisheries of eight thousand eels. In the Earl of Morton's land at Leckonfield, there was a fishery yielding four thousand eels, and in William de Percy's land, at the same town, ten fisheries yielding two thousand four hundred eels. A great part of the woods of Deira, as well as of its marshes, remained at the era of the Survey; for we find at Beverley wood pasture three miles long, and a mile and a half broad; at Leckonfield, in Earl Morton's land, wood pasture one mile long and one mile broad; and in Percy's land, wood pasture two miles long and two broad; not to speak of other large tracts of wood in the same quarter.‡ The names of Woodman*sea* near Beverley, and Rot*sea* near Watton, bespeak the existence of *meres* in those places. Indeed Watton itself derived its name from the *wetness* of its situation; being surrounded, like Melsa, by waters and marshes.§

Woods, marshes, and fisheries of eels abounded also at the era of Domesday, in the neighbourhood of Howden and Cave, and in

* Nemoribus et frutetis consitum, aquis et paludibus cinctum. Dugdale's Monast. I. p. 793.

† Onoýnapuoa. Bed. Hist. L. V. c. 2.

‡ Bawdwen's Domesday, p. 55, 80, 169, 202, &c.

§ Its Saxon name was Wetaoun— *Wet-town*. Bed. Hist. L. V. c. 3.

the flat country on the other side of the Humber and the Ouse, towards Thorn and Hatfield. At Tudworth near Hatfield were twenty fisheries yielding twenty thousand eels.*

Yet, in these respects, the southern part of Yorkshire was far exceeded by the adjoining county of Lincoln. A large division of Lincolnshire obtained, in Bede's time, the name of *Lindi-sey*, the *sey* of *Lindum* (the Roman name of Lincoln), as being almost covered with meres and woody marshes.† The quantity of wood pasture, coppice wood, meadow land, marsh land, and eel fisheries, entered in Domesday as belonging to Lincolnshire, is immense. Thus in the King's land at Kyme, were two hundred and ten acres of wood pasture, seven hundred acres of marsh, and six fisheries; besides what belonged there to other proprietors. The bishop of Lincoln had in Corby, eleven hundred acres of wood pasture; in Bitchfield, seven hundred acres; in Sleaford, three hundred and twenty acres of meadow, and three hundred and thirty acres of marsh; in Louth, four hundred acres of wood; and in Cainby, four hundred acres of meadow. In the two Mintings, were two hundred and sixty acres of meadow, one hundred of wood pasture, and one thousand and ten of coppice wood. In the Isle of Axholme, between the Trent and the Dun, there was then a marsh, ten miles long, and three broad. Vast quantities of woods and marshes stretched along the south bank of the Humber, and the Lincolnshire coast. At Barton were two hundred and forty acres of meadow, and coppice wood two miles long and one broad; and at Ferraby, near Barton, were two hundred and ten acres of meadow, and two hundred and sixty acres of marsh. Earl Hugh had in Wainfleet, and its dependencies, a thousand acres of meadow, twenty salt pits, and eighty acres of coppice wood; and in Huttoft, Sutton, and some adjacent places, seven hundred and

* Bawdwen's Domesday, p. 161, &c. † The same district is still called *Lindsey*.

eighty acres of meadow; besides what other proprietors had in the same places.* These last instances have been quoted, chiefly because the boggy islets, on the Lincolnshire coast, examined by Sir Joseph Banks and Dr. de Serra in 1796, lie opposite to Huttoft and Sutton.† As the sea appears to have made very great inroads on the coast, at no very distant date, it may be presumed, that the moory islets now discernible, are fragments of what was meadow or marsh land at the era of Domesday.

An extensive chain of meres has skirted the shores of Lincolnshire, so that their bottoms, now exposed to the sea, form almost one continued morass. The barrier which for some ages secured them against the inroads of the ocean, has long ago been broken through; yet we need not doubt that such a barrier once existed. If any should allege, that they are of too great extent to have been so secured, let them recollect, that there are fens or meres in Lincolnshire, of great extent, from which the ocean is still shut out. Were the sea to break into these fens, their bottoms would become another large morass, similar to what is now exposed along the shore. So early as the reign of the Conqueror, the sea had commenced its inroads on this coast; for we find it stated, concerning some land at a place called Wrangle, that "it was waste on account of the flowing of the sea."‡ As there were a few places on the coast with the term *Dic* or *Dyke* occurring in their names, it seems probable, that some dykes, or artificial barriers, were constructed even at that distant era, to check the encroachments of the ocean.

With respect to the morasses on the banks of the Humber and its tributary rivers, it is most probable, that they have been formed, at a remote period, in consequence of the obstruction of the mouth

* Bawdwen, p. 419, 479, 513, 562, 602, &c. † See Philos. Transactions for 1799.
‡ Bawdwen's Domesday, p. 592.

of the Humber. It is certain, that the mouths of large rivers are subject to great variations, being sometimes quite open, and sometimes greatly obstructed by the formation of sand banks or mud islands. Such shoals have existed, and still in some degree exist, at the mouth of the Humber; and we may easily believe, that at the distance of some ages, the mouth of this river was so choaked up, as to allow only a very partial flow of the tide, and occasion a large accumulation of fresh water on all the flat lands through which this river and the streams that feed it hold their course. An obstruction of this kind would necessarily produce large meres and marshes, throughout the woody plains of Deira and of Lindisey.

But here a question arises, which indeed might have been started sooner, How came the bottoms of these meres or lakes to be so replenished with decayed trees, and other vegetable matter, as to acquire the nature of peat bogs? To this we answer, that various causes may be assigned for this fact. Even in the ordinary course of nature, wherever there are fresh water lakes situated in woods, a deposition of vegetable matter will gradually take place in the bottoms of the lakes, from the annual fall of leaves and decay of plants and shrubs, and the occasional fall of withered branches and trunks of trees. This natural process of decay will, in the lapse of some ages, yield a thick stratum of vegetable matter, as may be seen in the woods of America. But it is evident, that the hand of man has greatly accelerated the accumulation of this matter, in the bottoms of our lakes or meres. Some think, that our ancestors, in clearing out the land for the purposes of agriculture, threw the trees into lakes and ponds and hollow places, as the easiest way of getting rid of them; wood being with them of no more value, than it is now in the back settlements of America. This is Dr. Plot's opinion. The fact under consideration, however, is far more likely to have resulted from the arts of war, than from those of peace. It is well known, from the testimony of

Cæsar, Tacitus, Dion Cassius, and other antient historians, that the Britons had their fastnesses to which they fled after any defeat, in woody marshes, whither the Romans could not easily follow them; and that it was therefore a part of the policy of the Romans, to cut down the woods, and fill up the marshes and lakes with the trees. By this scheme, which was carried on to a great extent, and in completing which the vanquished tribes were compelled to assist, the Romans secured their conquests in Britain; for the natives having no place of retreat left, were compelled to submit.

That such has been the principal cause of the accumulation of wood in our lakes and marshes, may be inferred from the appearances observed in cutting large drains, or new rivers, in the marsh lands of Hatfield Chase, above a century ago. Among the vast quantities of trees then discovered, many bore the marks of the axe, others appeared to be split with wedges, and not a few exhibited evident traces of fire; indicating, that that element had been employed in the destruction of the British forests. The discovery of several Roman coins, in digging these drains, particularly some coins of Vespasian, serves to shew the time when, and the people by whom, this destruction was effected. Other works of art were also found, some of which might be Roman, and some British. The canoes found occasionally in these ancient bogs, were probably those which the Britons used in navigating their lakes and rivers.*

A great number of the trees in these bogs appear to have grown on the spots where they lie, their roots, from which they have been broken or cut off, being found beside them in their natural position. It is stated, however, both in Mr. De la Pryme's paper now referred to, and that of Dr. Richardson concerning the fossil wood at Youle or Gowle,† that the trees in these bogs generally lie in the direction

* See De la Pryme's Paper in the Philos. Trans. for 1701. † Philos. Trans. for 1697.

of the current of the rivers in that quarter, having their tops toward the north-east. This suggests the idea, that the Romans not only filled up stagnant pools with the wood which they cut down, but threw quantities of trees into the rivers, which being carried down by the currents were lodged in abundance upon the adjacent banks.

Following this idea a little further, may we not conjecture, that the obstruction of the mouth of the Humber might be caused by an accumulation of this floating wood, which lodging in the mud would become a nucleus or basis for new islets or shoals. These mud banks being held together, and in some degree consolidated, by the timber, might for some ages be a barrier at the mouth of the river, both impeding the influx of the tide, and the current of the fresh water. In that case, the river stemmed by this new bar, behoved to rise higher, so as to flow over it; and this rise of the river would inundate all the flat country along its course, covering the plains far and wide, where the woods had lately been cut down, and where some remains of the ancient forests were still left. Hence the waters, stagnating in low places over the felled trees, and other vegetable substances, would in the course of some years convert them into peat bog; and the winter floods would deposit, over this boggy stratum, successive layers of mud, sand, and gravel, forming a soil adapted for vegetation.* The obstructions at the mouth of the river being gradually removed, after the lapse of several years, the waters would retire from the lands which they had inundated, leaving extensive tracts of soft spongy grounds, covering the ancient surface, and even the peat bogs, to the depth of several feet; while large meres and marshes would still

* Several curious observations on the formation of peat moss in the bottoms of lakes and on the banks of rivers, and of meadow land over the peat, may be seen in the first Volume of De Luc's Geological Travels. We might have noticed, when speaking of the termination *sea* or *sey*, that *see* is the usual term for *lake* in the north of Germany; of which numerous instances occur in De Luc's Map.

remain here and there, particularly in low and hollow places. The rapid growth of trees and plants in the new formed soil, would contribute to the increase of that soil, and serve to retain the moisture with which it was saturated.

Thus we may account for the phenomena presented by these submerged forests, without having recourse to the operation of earthquakes, or any preternatural elevations or depressions, either of the ocean, or of the land. The accumulation of an alluvial soil of sixteen or twenty feet in thickness, over these vegetable remains, is no difficulty in the way, especially as there may have been successive obstructions and inundations, and consequently a greater number of depositions. We have good evidence of the rapid growth of soil in low grounds, particularly on banks of rivers. The Roman pavements discovered in our times are almost all at a considerable depth below the present surface; and in tracing the remains of our Roman roads, however distinctly we may see them on the high grounds, we are almost sure to lose them in the hollows, where they are deeply covered by the soil. That the land on the banks of the Humber was increased at some periods, as it was diminished at others, appears from the records kept by the monks of Melsa; who state, that after the frequent and violent inundations of the Humber had destroyed no small quantity of land at their grange of Ald-Saltagh, and forced them to remove their grange into the interior, the land near the Humber began to grow again.*

Perhaps it may be alleged, that the low situation in which these peat bogs are found, militates against the opinions now advanced, and favours the idea of a subsidence of the land, or an elevation of the sea; most of the bogs, where they are laid open on the shore,

* Dugdale's Monasticon, I. p. 795, 796. The renovation of some part of their lost territory is thus mentioned: "Contra quem locum, licet Humbria ibidem terram propius consumpsisset, terra jam recrescere cœpit."

being visible only when the tide is out. Let it be remembered, however, that the bottoms of meres, or fresh water lakes, are often below the level of the sea; and this might be the case with many of our meres. Besides, might there not be a subsidence of the bogs themselves, where they open towards the sea, or any large river, without any general sinking of the land? In piercing through the alluvial beds near Hull, it is found, that beneath the peat bog there is a thick bed of sand and clay, mixed with water, forming a kind of quicksand; and in sinking at Sutton and Mablethorpe, near the boggy islets above mentioned, there is found beneath the boggy stratum about twenty feet of very soft clay or mud. Now it is easy to see, that wherever the bog is exposed to the tide, or to the river, with any such soft bed under it, especially if that bed be of a considerable thickness, there must be a partial subsidence of the bog; for the soft clay, or mud, or sand, having nothing to support it, will burst out, or be protruded, from under the bog; and the tide or current washing away the part first protruded, will make room for more; while the weight of the boggy stratum itself, and of the alluvium incumbent over it, must serve to press out the soft matter from beneath it; and thus a subsidence of the bog and its covering will take place, which will be greater or less, according to the softness and thickness of the stratum below, and the weight of the alluvium above. Some of the bogs connected with the Humber are known to have actually subsided a great number of feet, particularly those between Thorne and Gowle; and the boggy banks of the Humber may all have experienced a similar depression. Where the exposed bog itself is remarkably soft, the protrusion or compression of its own substance will sink the whole mass so much the lower.

We have dwelt longer on this part of our subject than may seem necessary; but the importance of elucidating topics that have been involved in so much obscurity, may serve as an apology for the length

of these discussions.— Let us now proceed to describe the regular strata of the district, beginning with

THE CHALK.

In this district, as in the south-east parts of England, the chalk is the uppermost rock, in respect of geological position. It holds a prominent place among our strata; and, as may be seen in the Map and Section, it is of very considerable extent, forming nearly the whole of those hills, or elevated grounds, denominated the Yorkshire Wolds. These chalk hills lie in the form of an arch, or bow, having one end at Flamborough Head, and the other near Ferriby on the Humber, while the middle part bends inwards, toward the river Derwent, making a sweep similar to the bend of that river, and in some places parallel to it. The middle part is by far the broadest, the distance from Driffield, where the chalk begins to sink under the alluvium, to Scagglethorpe beside Malton, being about fifteen miles; while at the two extremities of the bow, both that which touches the ocean, and that which reaches the Humber, the breadth is comparatively small. The Wolds, however, do not form one continued mountain, but are intersected or indented by several valleys, some of which are of considerable depth and extent. The curvature of the arch described by these hills is greatest towards its northern termination, where the chalk, commencing at Flamborough, takes a north-westerly direction by Hunmanby and Folkton (at which its most northerly point occurs); and thence proceeds west or west-south-west to Scagglethorpe. In this part of its course it is attended by the Derwent, which meeting the Wolds near Ganton, is forced to make a sharp turn to the west, flowing round the foot of the Wolds by Malton. From Scagglethorpe, the boundary of the chalk hills runs nearly south, or south-south-west, by Birdsall and Wilton; after which,

diverging from the Derwent, it takes a south-east course by Market Weighton to Ferriby, where it meets the Humber. The whole circuit thus described amounts to about sixty miles, without reckoning the sinuosities of the outline. The chalk stratum, after being interrupted by the Humber, re-appears on the south side of that river; and traversing Lincolnshire, continues its course, with a few interruptions, to the southern shores of England.

The highest parts of the Wolds are towards the outer edge of the arch which they describe; the interior part gently sloping from every side towards the plain of Holderness, while the exterior presents a bold and lofty front, or at least a steep declivity. The chalk first appears on the coast, above the level of the sea, about a mile north from Bridlington Quay. From thence it gradually rises towards Flamborough and Speeton, where it reaches the height of about 400 feet or upwards; there being precipitous cliffs at Speeton about 300 feet high, the top of which is many feet below the elevation of the adjoining heights. In proceeding westward, we find the back part of the Wolds assuming a much more lofty form. Wilton beacon is ascertained to be 809 feet above the level of the sea. The hills again diminish in height as they approach the Humber; yet at Hunsley beacon, only about six miles from Ferriby, the elevation is still 531 feet. At the same time, it must be observed, that the thickness of the chalk is not every where equal to the height of the hills; for where the Wolds are highest, we find some of the next strata, occupying the lower part of them, beneath the chalk. The thickness of the latter, however, cannot be less in some places than five or six hundred feet.

The dip of the chalk strata, as has already been intimated, is not in one direction only; for the slope of the hills, from each part of the semicircle which they form, being towards the centre, that is, towards the middle part of Holderness, it follows, that at Flamborough and Bridlington the dip is to the south; about Driffield and the middle

parts of the Wolds, it is to the south-east; and at Riplingham, Swanland, and other places near the Humber, it is to the east; which last is also the direction of the dip in Lincolnshire. Thus the chalk of our district forms a kind of basin, or rather half basin, in which the alluvium of Holderness lies; the chalk dipping beneath that alluvium on every side. The quantity, or angle, of the dip, is perhaps as various as its direction. Some have stated it at five yards in a mile; but in many places it is vastly greater, while in others it may be less. The distance from the heights near Flamborough, which we have stated to be 400 feet high, to where the chalk sinks below the level of the sea, is only about four miles; and the distance from Hunsley beacon, which is 531 feet high, to the plains of Beverley and Cottingham, can scarcely be more than five miles: so that the dip in each of these instances is 100 feet per mile. In other places, however, the declivity is much more gentle; and as we may presume, that nearly the same inequalities in the surface of the chalk exist under the alluvium, as we find in the hills, it is impossible to say, at what depth the chalk might be found, at any given distance from the foot of the hills. It is said, we know not on what authority, that at Sproatley in Holderness, the chalk is only 198 feet from the surface. According to the general dip of the strata, it ought there to be much deeper: but it is not unlikely, that the chalk, after descending, may rise in hummocks, forming little submarine, or subterraneous hills. This idea is countenanced by the fact, that a rock rises in the sea at Smithwick sands, opposite Fraisthorpe near Bridlington Quay, and is almost visible at low water: which rock may be presumed to be a part of the chalk, which there ascends almost to the surface, a few miles south from the place where it sinks below the horizon. The great height of the alluvium at Aldborough and its vicinity makes it very probable, that there also the chalk again bends upward; and this agrees with the account of its approaching so near the surface at Sproatley,

which is in the same quarter. Similar undulations in the chalk beds may be observed in Lincolnshire, and in the southern counties.

Chalk is a calcareous rock so generally known, that it is unnecessary to give a minute description of it. Yet it will be proper to make some observations on the structure of a bed which holds such an important station in our district; especially as our remarks may assist some of our readers in comparing the chalk of Yorkshire with that of other places.

In examining the chalk, in the quarries on the Wolds, and in the cliffs of Flamborough, we see the upper part of the bed not presenting a smooth surface, but broken and shattered, and intermixed with the alluvial soil, which is generally very thin. It is intersected by numerous fissures or seams, both parallel to the general bed, and perpendicular to it; so that it is easily divided into angular fragments. As we proceed downwards, the parallel seams, which constitute the chalk a *stratified* rock, become less numerous, so that the strata grow thicker and thicker; and as the perpendicular fissures, which are less regular than the seams of the strata, also diminish in number, the middle and lower parts of the great chalk bed are much more compact than the upper part. Indeed, as the broken chalk descends but a short way from the top, the great body of the chalk, but especially the lower part, has a massive appearance, with very few horizontal partings: and as it has a tendency to split in a perpendicular direction, in preference to a horizontal fracture, the chalk cliffs on both sides of Flamborough Head, and at the Head itself, have a beautiful columnar aspect. For the same reason, numerous recesses and caverns, some of them highly romantic, occur in these cliffs; particularly towards the extremity of the Head, where the waves of the German Ocean, beating with great force into the lower part of the perpendicular fissures, has hollowed them out into curious grottos and niches, and sometimes extensive caves, while the more solid

masses of the chalk remain as pillars to support them. The pillars themselves, after a lapse of years, successively give way, and the roofs of the grottos fall in; and as the work of excavation still goes on, the stateliness of some of the present caves is increased by the remains of the pillars and walls of more ancient grottos, forming a kind of porches or antichambers before them. Vast quantities of chalk in masses and fragments, rounded by attrition, lie scattered on the shore, from whence many large boat-loads are annually carried off, to be burnt into lime near Whitby, and on other parts of the coast.

It is scarcely necessary to observe, that in the more exposed parts of the cliffs, the upper or loose chalk is entirely gone, having been dissolved and thrown down by the winds and rains; and hence, along the greater part of the Flamborough shores, the compact chalk forms the highest verge of the cliffs. This is especially the case in the lofty Speeton cliffs, where the chalk rises in massive columns to the height of near 300 feet. Here the beating of the rains on the top of the cliffs, has produced an effect analogous to that of the dashing of the waves on the bottom towards Flamborough Head; for as there the waves have hollowed the lower part of the vertical fissures into caverns, leaving the more solid parts standing as pillars,— here the rains have produced deep sinuosities and breaks in the upper part of the same fissures, leaving the firm chalk between them in the form of tall pinnacles. A spectator from the beach almost imagines himself at the foot of a stupendous castle, whose lofty walls are surmounted by a range of magnificent towers. In some parts too, where the pinnacles have fallen off, and left the upper surface flat, the massive columns, having square angles, present the appearance of tall church towers without spires. The view of these chalk cliffs, from a convenient distance, is truly grand and picturesque; especially when the beams of the rising or setting sun are gleaming across them; the

contrast between the brilliancy of the tall milk white columns, and the shaded vertical recesses between them, being then the greatest.

No caves are found at the bottom of the Speeton cliffs, as the sea is less boisterous there than at Flamborough Head, and the cliffs are generally protected from its violence by a sloping mound, formed by the materials that have fallen from the rock above.

Yet, if the sea had free access to beat against the foot of these highest chalk cliffs, it would not make excavations of the same form as at Flamborough Head; for here the bottom of the cliff, where it is exposed, is found to consist of another species of chalk, which we may call the LOWER or COLOURED CHALK. This portion of the chalk strata has the same grain and fracture, and the same absorbent quality, with the great body of the chalk above described; but instead of assuming a massive appearance with vertical fissures, it lies in horizontal, or at least flat strata, generally of no great thickness, yet tolerably compact; and instead of a bright white colour, the greater part is of a dull white, with a greenish, and in some places a blueish tinge; while other parts are of a brick red colour, or rather of a duller red, approaching to chocolate colour. The red chalk alternates with the dull white, in large stripes, presenting a singular and interesting appearance. The dull white chalk grows darker as it descends, passing into a greenish or blueish grey.

The thickness of the coloured or lower chalk bears but a small proportion to the great mass of the chalk rocks, as it rises only a few yards in the face of the cliff, and at the places where it is seen, it cannot be many yards above the shale that succeeds the chalk strata. In point of hardness, there is no material difference; yet the white chalk may be called the hardest, especially when compared with the lowest part of the coloured chalk, which approximates in softness, and other qualities, to the shale upon which it reposes. This chalk, therefore, does not correspond with what is called the lower chalk

in the southern counties; for the latter is of a hard quality; but it does not appear to differ much from the argillaceous chalk or chalk marl, found below the hard chalk in these counties. It may be observed, however, that our white chalk is of a harder quality than some of the upper chalk of the south. The coloured chalk occurs beneath the white chalk in Lincolnshire, as well as in our district.

The remarkable conformation of these rocks, in having the upper and middle part massive, while the lower part is in thin flat strata, is not peculiar to the chalk hills. The same thing occurs in the magnesian limestone of the county of Durham; particularly at the Marsden rocks, between Sunderland and Shields. There the great body of the limestone appears massive, while below it there is a limestone of a different kind, arranged in thin strata, and even in some places finely laminated, its thin lamina when separated forming *flexible limestone*. The line between the upper and lower limestone may be distinctly traced; especially as the lower, being softer than the mass above, is often washed away by the sea, while the upper is left as a roof over the caverns thus excavated. A similar appearance may be observed in the hard porphyritic-looking rocks at St. Abb's Head in Berwickshire, which are usually designated by the harsh sounding name *grawacké*. The lower rocks form flat strata shelving towards the sea, while above them are lofty and massive rocks, rising in a kind of towers or columns, parted by vertical fissures.

Having described the chalk itself, it will be necessary before proceeding to the next strata, to take notice of some substances that are imbedded in it. Its organic remains, which are not very numerous, especially in the coloured chalk, will fall to be considered in another division of our Work. Here we would advert to minerals of a different description.

A soft *grey marl* resembling in colour the lowest beds of the grey chalk, is found in the fissures of the upper chalk; especially in the

seams between the strata. This substance does not seem to have belonged to the chalk beds originally; but to have been deposited by water percolating through the numerous fissures of the loose chalk, and carrying with it a solution of chalk, mixed with mud washed down from the alluvium. Some have called this marl *fullers' earth.*

Iron-ore is a mineral that occurs both in the white and the grey chalk: but with this difference, that in the latter it occurs only in the form of *pyrites,* in small nodules of crystals, having a beautiful greenish yellow metallic hue; whereas in the former, the ore is in nodules or small masses of a botryoidal form, having a ferruginous colour without, and a dull iron colour within. This ore may be called a kind of coarse *hæmatite,* as each protuberance of the botryoidal nodules, when broken across, presents the appearance of rays diverging from the centre. The external surface of some of the nodules seems like a collection of imperfect crystals, with numerous angles, points, and facets, having a lustre approaching to metallic. In others there is a rusty coating, the surface being deeply oxidated; and the rust not only covers the surface, but penetrates into the pores or cracks occasionally found in the nodules. Even the pyritous crystals in the grey chalk, often acquire a slight coating of rust, when long exposed to the action of the air and water. These crystals do not appear to exist in the red chalk.

In the upper chalk we also find, in small cavities, an ochreous or ferruginous substance, apparently the same with that which constitutes the coarse hæmatite nodules. Whether this substance has resulted from the decomposition of such crystallized nodules, or has never been crystallized at all, we cannot determine; but as nodules are often found in a half decomposed state, the former appears most probable. Wherever this ochreous substance is found, and indeed wherever these nodules are imbedded, the chalk is tinged with brown or yellow, around the cavity or bed. Hence the white chalk abounds

with ferruginous spots, which are larger or smaller, according to the quantity of the matter imbedded.

But the substance which occurs most plentifully in the white chalk is *flint*. This is well known to be the constant associate of the white chalk; and it has long been, and still is, a matter of dispute, how substances so different in their qualities have become so nearly related. Without agitating that question, at least for the present, we shall merely state the actual connection between the chalk and the flint, as it appears in our district.

Some have described the flint as interstratified with the chalk, stating that thin strata of flint are found alternating with thick strata of chalk; but on a minute examination of the chalk rocks, particularly at Flamborough Head, where they are most open to inspection, we can assure our readers, that the flint is not *interstratified* with the chalk, in the ordinary acceptation of that word, but merely *imbedded* in it. Sometimes it occurs in irregular tubercular nodules, and sometimes in flat pieces, like thin cakes: and as a number of these flat plates are often found nearly in contact with one another, or actually adhering or running into each other, on the same level or floor; when several of these lines of plates are seen rising one above another, as is sometimes the case, they present the appearance of alternate strata; especially as they usually run parallel to one another, and to the general bed. But if we follow any one of those seams, we soon find it to run out; and in searching for its continuation further on, instead of meeting with a seam or line of plates on the same floor, we may expect to find others a little higher or a little lower; or perhaps we may find a fresh seam commencing above or below it before its termination. This is something very different from an alternation of strata; especially as the seams are not continuous, except for very short distances; and the intervals between the pieces of flint are all filled up with the chalk, in the same manner as the intervals in rows of nodules in some of our schistose strata, are filled up with schistus.

The nodules and cakes of flint do not occur in the coloured chalk, but only in the white; and in the latter they are most abundant in the middle parts of the beds, being very scanty in the loose chalk near the surface, and still more so in the lower part of the white chalk, where it passes into the grey chalk. The flint is very plentiful among the excavations at Flamborough Head.

The flint, as well as the chalk, sometimes contains organic remains. It may also be observed, that many of our nodules of flint, when broken, exhibit a variety of colours, as yellow, orange, blue, &c.: and these colours are sometimes disposed in concentric zones, and sometimes in a clouded irregular form, not unlike the Egyptian pebbles.

The bed that immediately succeeds the chalk may be designated

THE UPPER SHALE.

A great variety of the beds in our district come under the denomination of *shale,* or *schistus.* Some of these beds are *bituminous,* or *coaly;* some *arenaceous,* or *sandy;* but a much greater number *argillaceous* or *aluminous,* containing a large proportion of *clay.* Their colour varies according to their ingredients, the coal shale being blackish, the sandy shale light grey, and the clay shale usually dark grey. The last two have sometimes a blueish tinge; and we may add, that the clay shale is often found of a very dark colour, approaching to black; especially in the recent fracture. In some instances it is of a pale grey colour; and very often, the exposed surface acquires a ferruginous hue. The sandy shale is frequently micaceous, abounding with specks of the shining substance called *mica.* These three kinds of shale cannot always be correctly distinguished, as they often pass into one another, and the different qualities assigned to them may sometimes be found blended together in the same bed. All the beds

agree in having the same schistose or slaty structure, easily splitting into thin lamina, from whence they have the name *schistus* or *schist*. They possess various degrees of induration, but are all comparatively soft, scarcely deserving to be denominated *rocks*.

The shale or schist that succeeds the chalk, which we call the UPPER SHALE, as being higher in geological situation than any other shale bed in the district, is of the argillaceous or aluminous kind, or what is frequently termed *slate-clay*.* This bed is seen to most advantage on the shore below Speeton, rising behind the chalk, to the height of 150 feet or upwards, and extending along the shore about half a mile. In some parts, the shale is concealed by, or blended with, the alluvial covering; but at its junction with the chalk, it is quite bare and distinct.

Had we no other means of ascertaining the relative situation of the chalk and the shale, than the appearances presented at their junction in the Speeton cliffs, we might suppose that, instead of the one running beneath the other, they are only placed in juxtaposition: for, as may be seen in the Section (where *b* denotes the chalk and *c* the upper shale), the shale is too elevated to be considered as running beneath the chalk, were they in their original position. A deep channel worn by a rivulet separates between them, and were either or both extended a few yards, in the line of their dip, they would abut against one another, but the shale could not go under the chalk, except at the very lowest part of the shale bed. We have the best means of knowing, however, that the shale does run under the chalk, and lies under it in a conformable position; for not only do we find it *cropping out* (as the phrase is) from under the chalk, at Knapton, Thorpe-Basset, Settrington, and other places, but its situation has

* Some also apply to it the term *clay-slate*, but that name ought to be appropriated to the hard clay-slate used for roofing.

been ascertained by boring through the chalk. In 1818 and 1819, Mr. George Rivis of Sherburn bored for coal in a deep dale about a mile and a half south from Staxton. The boring was continued to the depth of 114 yards; and after passing through the white chalk, and the red and grey chalk, the borers came to the blue shale or clay, at the depth of 96 yards from the mouth of the bore; so that the boring for the last 18 yards was entirely in the clay. Specimens of the shale, and of the red and grey chalk, taken from the bore, were received by the authors from Mr. Rivis. Some beautiful crystals of pyrites were found in the grey chalk, as at the Speeton cliffs.

According to the statement of the borers, a small seam of bituminous inflammable shale was pierced through at the depth of five yards and a half from the surface, and at some distance below, a small seam of excellent coal: but as no such seams are observed in the chalk cliffs, nor any where else in the chalk strata, as far as we have heard, there is great reason to suspect, that the proprietor has been imposed on, to encourage him to persevere in his fruitless search; and that the bituminous shale and coal, if extracted from the bore, were previously thrown into it.

The thickness of the chalk on the heights of the Wolds near this boring, must be very considerable, as it was found in this deep dale to descend below the surface 96 yards, or near 300 feet. How much of this depth is occupied by the coloured chalk, the authors did not exactly learn, except that, as at Speeton, its thickness bears but a small proportion to that of the white chalk above it. Indeed, as the white chalk appears to pass gradually into the grey, it is difficult to fix the precise limits of each.

In proceeding westward from Staxton, behind the Wolds, we have access to examine the shale, as at Speeton, without the aid of borers; for, the chalk rising to a great height, the shale rises along with it, and crops out from beneath it. At Knapton it is found on

the slope below the chalk hills, about half a mile east from the village: and here the clay is dug out, and employed in making a compost to improve the soil of the adjacent fields. And truly the soil has need of a mixture of clay, for it is so light, that the wind, when it is violent, blows it away in vast quantities; as the authors found in one of their excursions to their no small annoyance, being here enveloped for some time in a thick cloud of dust, raised up from the ploughed fields. At Thorpe-Basset, a little further west, it is found in the slope above the village, when the ground is opened to the depth of a few feet. It has been met with in sinking wells, and the authors observed it at a pond which had been recently deepened. Advancing further to Settrington, we find the shale on the sides of the road descending from the Wolds, near the house of Lady Sykes, and continuing down the bank for a considerable space. It may be found no doubt in many other spots, behind the higher Wolds, though in several places it appears to be deeply covered with the alluvium.

In one of the clay pits at Knapton, we see the junction of the shale with the red and grey chalk. The clay, where it joins the chalk, is soft and plastic; and this also is the case with the lower part of the chalk. The two substances are partly blended together; the soft chalk, which occurs here of both colours, approaching to the state of red and grey clay; while the clay that is next the chalk is somewhat impregnated with calcareous matter, and is almost divested of its schistose quality. The same facts are observed in the specimens from the Staxton boring, and at the junction of the chalk and shale in the lower part of the Speeton cliffs. By digging in the bottom of the water-course formerly mentioned, between the chalk and shale at Speeton, it has been found that the coloured chalk is nearly in the state of clay, at the junction, and that both it and the clay are soft and plastic.

It is obvious, however, from the facts above stated, that in the Speeton cliffs, the chalk and the shale are not lying in their original

position, at least in respect of the greater part of their respective masses, at the place of junction. Their present relative positions cannot be accounted for, but on the supposition of a dislocation of the strata, similar to what we shall have to notice hereafter, in not a few instances. The chalk must have slipped down in an immense mass upon the shale, and displacing it by the pressure, forced it up into its present elevated position. The appearance of the chalk at this point, and its known tendency to split vertically, confirm this idea. On a careful inspection of the chalk cliff over the shale, we can perceive that large portions of the upper chalk have descended from a higher station to that which they now occupy; though the uniformity of their colour, and their retaining the same vertical position in their columnar masses, serve to conceal the dislocation. Even the coloured chalk has not been exempted from this kind of violent abruption; for at a little distance from the junction with the shale, we find a break in the cliff, rendered very conspicuous by its crossing a seam of red chalk, which is higher on one side of the fissure, and lower on the other.

The softness of the slate-clay would make it more easily forced out of its natural position by the descent of the chalk: for though in the greater part of the bed it is not plastic, but has its proper schistose form, still it is much softer than the aluminous schistus in the great bed on the Whitby shores; and it is not interstratified with any of those seams of sandstone or limestone, which, usually intersect and strengthen the beds of schistus. It contains, however, like our other beds of shale, a great number of septaria and other nodules, with numerous petrifactions; and as some of the petrifactions, particularly among those found at Settrington, appear imbedded in fragments of a kind of schistose argillaceous limestone, it is not unlikely that a seam of that description may exist in the lower part of the schistus. Some of the nodules containing petrifactions, found

in the Speeton shale, are of a chalky nature. The septaria are not unfrequently in a shape resembling the tortoise, being oblong, with the lowest side flat and the upper rounded; and when they occur with the *septa* or divisions, from whence they have their name, appearing through their outer crust in distinct lines or markings, the resemblance is so great, that they are actually collected and sold as petrified tortoises.

This shale, like most other beds of slate-clay, also abounds with crystals of *selenite*. The most beautiful specimens are found at the oldest clay pit at Knapton. They sometimes occur in flat rhomboidal crystals, with bevelled edges: but more frequently in oblong flat pieces, but with the angles and facets, at their terminations, corresponding with those of the rhomboidal pieces. In the same clay pit, the authors found some good specimens of those branching tubes, not unlike the roots of furze, formed by oxide of iron, percolating through the clay in a fluid or moist state. It is proper also to observe, that iron pyrites abounds in the nodules that occur in this shale, as in almost all the shale beds of the district.

Had this bed occurred above the chalk, instead of lying under it, there is no doubt that it would have obtained the name of the *London clay;* for, as far as can be judged by the descriptions given of the latter, the two beds are remarkably similar, both in their substance and their contents. It is not, however, in this district alone, that shale of this description is found under the chalk. In Cambridgeshire the grey chalk rests on an extensive bed of blue clay, provincially called *gault*. The grey chalk is there of much greater thickness than in our Wolds, as it composes the greatest part of the hills of Cambridgeshire. It is also of a much harder quality; yet, like our grey chalk, it becomes argillaceous, soft, and of a greenish hue, where it joins the clay. It contains pyrites, but appears to differ from our lower chalk, in being entirely grey, without any mixture of

red stripes.* A similar bed of slate-clay occurs under the chalk in the north of Ireland, containing thin seams of argillaceous limestone, with petrifactions of the same kind with those in our upper shale. In most places, however, a bed of what is termed *green sand* is interposed between the clay and the chalk. The greenish colour of the lower part of our chalk, may make some fancy it to correspond with the green sand; but it can with no propriety be called *sand*, for it is not arenaceous. The bed of slate-clay, with seams of argillaceous limestone, now mentioned, has been termed *lias*.†

The shale bed, like the chalk above it, must vary considerably in thickness; but it is probably not more than between two and three hundred feet thick, if it ever exceeds two hundred. It is thickest, as may be expected, behind the highest part of the Wolds, as at Settrington. There it may be traced to a considerable distance down a steep bank; though in several parts of the bank, particularly at the foot where the declivity is gentle, it is covered by the alluvium, which, filling the bottom of a narrow valley through which a small stream flows, conceals the junction of the shale with the next member of our strata, viz.

THE OOLITE.

The cliffs in Filey bay furnish no evidence respecting the beds that immediately succeed the upper shale; for behind the shale we find nothing but an alluvial cliff, extending from thence to the rocks called Filey Bridge, a distance of above two miles, in which the regular strata are wholly interrupted. At Settrington, however, and along the eastern skirts of the Langton Wolds, we find the slate-clay succeeded by that remarkable kind of limestone called *oolite* or

* Geological Transactions, III. p. 243, 248, 249. † Ibid. p. 164, 165, 211, &c.

roestone; which dipping towards the chalk and the shale, in a conformable position, no doubt runs beneath them. After crossing the stream at Settrington, above mentioned, on the south side of Settrington, and ascending from it along the Malton road, we find ourselves immediately on the oolite, quarries of which are opened on the side of the road. There is no doubt, that the narrow valley marks the line of separation between the shale and the oolite.

The oolite limestone, and the beds of calcareous sandstone, or sandy limestone, usually attending it, occupy an extensive range of hills, surrounding the vale of Pickering, except where it is bounded by the chalk hills. This range, commencing with Oliver's Mount and Seamer moor near Scarborough, and Silphoue moor between Hackness and Harwood Dale, proceeds westward by Langdale, Saltergate, Newton, Cropton, Spaunton, Gillimoor, and Hawnby, as far as the Hambleton hills, the highest point of which is 1246 feet above the level of the sea. The western boundary terminates in the lofty precipices called Rowlston scar and Whitestone cliff, or the White Mare, overlooking the vale of Thirsk. From thence the boundary turns round in a south-east direction, proceeding by Wass bank, above Byland abbey, and by the vicinity of Castle Howard, where the hills become very low; then crossing the Derwent near Whitwell, passes by Westow, and along the southern skirts of the Langton Wolds, till it reaches the chalk hills.

Thus these limestone hills circumscribe the whole of the vale of Pickering, except where the chalk projects into it: and, with the exception of the Langton Wolds, where the oolite dips towards the shale and the chalk, they all dip more or less towards that extensive valley; the Seamer hills having a declivity towards the south-west, the long range on the north of the valley dipping south into it, the hills near Kirby Moorside dipping south-east, those to the west of Helmsley dipping east, and those to the south of Helmsley, and from

thence to Malton, dipping north, while they also have a declivity to the east, in the direction of the Wolds. The middle of the vale of Pickering may therefore be considered as the centre of a basin, formed by the oolite hills, which dip into it from all sides, except on the south-east, where the chalk and shale make a sweep into it. In a part of the east end of the valley, however, towards Filey bay, the oolite is entirely gone, and its place is occupied by a deep alluvium.

It will be seen, from the description now given, that the bend of the oolite hills does not run parallel to that of the chalk hills, but makes a much greater sweep to the west; at the same time the one bears a resemblance to the other, particularly in this respect, that the highest part of each range is towards the north-west, and that each after arriving at that point makes a sudden turn to the south-east. To this we may add, that as the chalk rises again in some places, after it has sunk under the great alluvial bed in its bosom, so the oolite presents the same undulations, and to a greater extent, rising in hummocks in various parts of the vale of Pickering, especially towards its western termination.

As it is our design, in this part of our Work, to state facts, without proposing theories, we do not mean at present to inquire particularly into the causes of the phenomena here exhibited: yet we can scarcely avoid remarking, that they cannot well be accounted for, without supposing that a great subsidence of the strata has taken place in the vale of Pickering. If we suppose the strata in that valley, especially on the south and south-east sides of it, to have sunk down, and a washing away of the upper part of the strata towards the sea to have also taken place, before the deposition of the alluvium, we can easily conceive why the oolite has disappeared at Filey bay; and why the oolite hills, encircling the valley, generally dip towards it, as well as towards the chalk. The same supposition will also explain, why the oolite between Settrington and Malton

presents many abrupt rocks fronting the same valley; as these rocks, forming the northern border of the Langton Wolds, seem to mark the extent of the disruption in this direction, being apparently the continuation of those strata which once covered the space that is now a valley, by the breaking off and subsidence of which strata the valley has been formed. On the same principle, we may account for several other irregularities in these hills, particularly on the south side of the valley; where the strata are in some places very flat, and in others elevated, with great variations in their dip, and not a few breaks and interruptions.

On the north side of the valley, the hills in general have a remarkably uniform appearance. Their southern faces gently slope into the valley; their upper surface spreads into extensive flats, nearly level, as in what are called *table* mountains; and, on the north, they terminate abruptly in a steep but smooth declivity, forming an angle of about forty-five degrees with the horizon. In this respect there is a striking difference between the escarpment of these hills, and that of the chalk hills. The chalk hills, except in the sea cliffs, have their north fronts rounded off, and often exhibit a chain of round knolls, particularly near Heslerton; but the flat summits of the limestone hills usually preserve their level to the very verge of their northern fronts, and as these fronts descend in a regularly inclined plane, the profile of each hill appears like the junction of two straight lines, the level line and the line of escarpment. Hence, as the same angle of inclination prevails almost universally, a range of projecting points in the fronts of these hills, viewed in profile, presents the appearance of regular works of art.

The same uniformity is not observed among the hills on the south and south-west of the valley; for though they have for the most part flat summits, there is a considerable variety in the form of their fronts; some of them, as has been noticed, presenting bold perpendicular

cliffs, instead of regularly inclined planes. The Howardian hills, indeed, can scarcely be said to have any line of fronts, as they generally swell and fall by gentle undulations. Yet several projecting points, from these hills, stretch into the vale of York; and the appearance of some of these points exhibits a degree of regularity, approaching to that of the northern oolite hills.

In speaking of this chain as the *oolite* hills, we do not mean to intimate, that they are wholly or principally composed of that kind of rock; but the name may be adopted, as the oolite forms a most important feature in these hills, being the highest bed in the series of which they are composed, and generally the thickest bed. This rock is called *oolite* or *egg-stone*, as a great part of its substance consists of minute globules, like small eggs, such as we see in the roe of a fish; for which reason it is also called *roe-stone*. These globular concretions are of various forms, being sometimes oval, though more frequently round. They also vary in size, some being as large as mustard seed, or even larger, while others are so minute that they can scarcely be discerned by the naked eye. They are not petrifactions, but have their origin in a peculiar kind of crystallization; being analogous to the large globules that appear in a variety of the Sunderland limestone, the crystalline structure of which is sufficiently obvious. Petrifactions, however, particularly shells, abound in the oolite to a degree almost incredible; most of this bed appearing as if it had been composed of a mass of shells, having their cavities and interstices filled up with the oolitic substance. Hence, as that substance is more easily decomposed than the shells, the fronts of old quarries in the oolite often present the appearance of grotto work, richly bestudded with shells.

The colour of the oolite is generally light grey, sometimes approaching to white, sometimes ash grey, and sometimes yellowish grey. In some places we find patches or stripes that are blue, or

blueish grey. Where there are most shells, the colour is usually darkest, the substance of the shells, which is for the most part sparry and highly crystalline, having a watery or flinty aspect. The *ova*, or small globules, often look whiter than the matrix or cement in which they are imbedded; but this may be owing to the greater smoothness of their surfaces, the cement having a more dull and marly appearance.

The oolite bed varies in thickness, from a few feet to fifty or sixty feet; and at Pickering and some other places its extreme thickness rather exceeds sixty. It is regularly stratified, having seams parallel to the general bed; which seams, as in the chalk, are most numerous in the upper part of the bed, the lower part being generally more compact and massive. These seams are crossed by a number of vertical fissures, which often descend into the beds below the oolite. The seams and fissures abound with marl or decomposed lime; and in the vertical fissures, we find vast quantities of *calc-spar*, in a great variety of forms. Some of the forms which it assumes are very beautiful, especially where the fissures are not filled up, but merely lined with it; in which case we often meet with the fine pyramidal crystals called *dog-tooth spar*.

Among the substances occurring in the oolite, it is necessary to mention some singular nodules, that are found in the quarries at Thornton, and other places. They are highly siliceous, yet not without some mixture of calcareous matter, particularly on the outside, where *ova*, or globules, like those of the oolite in which they are imbedded, occasionally appear. The nodules are usually of a pyriform or oblong shape, like some of the madrepores found in the chalk, and part of them are real madrepores, but in others no distinct organization can be perceived. Their chief ingredient may be called *chert* or *hornstone*. This forms the exterior part, while in the interior is a kind of *nucleus* of chalcedony with a mixture of agate. The chert is of various colours, being in some specimens light grey, and in others of a

darker colour, approaching to that of flint, but curiously mottled with small brownish or purplish spots, with a minute light speck in the centre of each. Some of the nodules are fine hexagon madrepores, which have been met with, not of a pyriform shape, but in flat masses. The occurrence of chert in limestone is considered as analogous to that of flint in chalk; and the analogy is borne out by the fact, that chert also occurs in some limestone strata in thin beds or seams, as flint does in the chalk.*

The numerous vertical fissures in the oolite and the beds immediately beneath it, are receptacles for water, as well as for marl and spar. Most of the rain that falls on the oolite hills, particularly those on the north side of the vale of Pickering, is immediately imbibed by the light soil that covers them, and sinking into the fissures, runs down the declivity of the hills in subterranean streams, which burst out at the foot of them in copious springs, nay, even in mighty torrents. Hence these hills are remarkably dry, and a great part of the valleys that intersect them are streamless. It is rare to find a spring amongst them in any elevated situation, and wells of water cannot be obtained without sinking to a great depth. The well at Cropton is no less than 216 feet deep. Hence also, as all the springs from these hills break out at the base of their declivities, where they descend into the vale of Pickering, a chain of towns and villages skirts the foot of the hills all around, built at these springs for the sake of their copious waters.

At the mouths of several of these springs, particularly the smaller springs, we find incrustations of moss and other vegetable substances, on which the waters have deposited the calcareous matter with which they are impregnated. Many of the springs, however, are too copious, and burst forth too violently, to admit of such depositions. At

* Geological Transactions, IV. p. 420. Bakewell's Geology, p. 388.

Keldhead near Pickering, the river Costa rises up from the earth at once. At Brompton a similar volume of water issues from the oolite, and is collected at its very source into a large mill-pond, so that it drives a mill in descending from the ledge of rocks out of which it springs. Phenomena of the same kind are observed at Ebberston, and other places.

These cavernous hills not only absorb their own waters, but swallow up the rivers and streams which pass through their intervals from the hills beyond them; for these currents, on reaching the limestone beds in their channels, sink down into the fissures, through which they flow under ground till they arrive at the valley, when they burst up again, like new springs, forming a part of the chain of springs surrounding the valley. Yet a channel is left above ground also, to convey the surplus waters, which the subterraneous channel, in some parts of the year, is incapable of admitting. The Rye sinks a little above Helmsley, and rises at a small distance from its proper channel, about a mile below. The Riccal disappears about a mile above the new bridge on the Helmsley and Kirkby Moorside road, and rises at Haram, a mile below, a few yards from its channel. Hodge beck descends into the rock, a few paces below Holme Caldron mill, near Kirkdale church; and bursts up again in the frightful basin of Howkeldhead, on the south side of the road, a mile west of Kirkby Moorside, and about a quarter of a mile east of its channel. The Dove, or Dow, sinks about twenty yards below Yawdwath mill, and after running nearly half a mile under ground, resumes its old channel about a furlong above Keldholm bridge. Hutton beck, or Catter beck, disappears about a mile north of Catter bridge, on the Kirkby Moorside and Pickering road, and starts up again about half a mile below. In like manner, the Seven is swallowed up a little above Sinnington, and reappears in its own channel, not all at once, but by successive risings, between Sinnington and Normanby. Thus, in skirting the

foot of these hills, the traveller crosses a succession of subterraneous rivers.*

On examining the bed of Hodge beck, where it sinks above Kirkdale church, we find, that the seams, or openings, between the strata, contribute to the absorption of the waters, as well as the vertical fissures. These seams, in some parts of the channel, particularly in the beds below the oolite, are numerous and open, the strata being thin and slaty; and, the dip of the strata being more rapid than the descent of the channel, the seams successively open towards the current, ready to receive its waters, like the buckets in an *over-shot* mill-wheel.

The tendency of the strata in these hills to split vertically, may be supposed to have facilitated the subsidence of the strata, presumed to have taken place in the vale of Pickering. On the other hand, that subsidence, if such there has been, would have the effect of multiplying and widening the vertical fissures. In a rock near Kirkdale church, there is a fissure where the appearance of the strata gives sufficient evidence of a dislocation, the strata on the side of the fissure next the valley being lower than the corresponding strata on the opposite side.

As the principal streams which water the vale of Pickering have not their sources in the oolite hills, but in the hills beyond them, the channel of each of those streams makes a complete section through the oolite and the series of beds connected with it. In such channels, it is not uncommon to find dislocations, or slips, of the strata, to which indeed these channels may owe their origin. For instance, the opening of Newton Dale at Pickering, bears marks of such a dislocation, the oolite on the east side of the stream being higher than the corresponding bed on the west. In the channel of the Derwent

* History of Whitby and the Vicinity, II. p. 774.

also, in which all the waters of the vale unite, the same phenomenon is observable, at and below Malton; but there the strata on the west side of the river are higher than those on the east side.

Whether the oolite accompanies the chalk and shale in their whole progress towards the south, is not known: but it is found behind the chalk at Ketton in Northamptonshire, at Bath, and as far as Portland isle. Yet the Bath stone and Portland stone appear to differ from our oolite, in their being better adapted for the purposes of architecture. Our oolite is chiefly useful in being burnt for lime, for which purpose large quarries of it are opened all around the vale of Pickering.

The beds that immediately succeed the oolite are

LIMESTONE AND CALCAREOUS SANDSTONE.

The oolite, as has been intimated, is the uppermost of a series of beds, composing the hills that encircle the vale of Pickering on all sides, except where it is bounded by the chalk hills. The series following the oolite cannot be very easily described; the beds being numerous and diversified, and varying both in number, thickness, and quality, in the different places where they are accessible. They all agree in being more or less calcareous; but this quality they possess in very different degrees; some of them being limestone, others sandstone, while the greater part are of an intermediate character.

Though scarcely any of these beds can be compared to the oolite in thickness, the whole together are vastly thicker, especially in the most lofty of the hills. Their extent too is considerably greater than that of the oolite; for though the latter is always uppermost, where the series is entire, it is often discontinued on the heights, without reaching the exterior fronts of the hills. Thus, between Pickering and Whitby, the oolite is discontinued a little to the north of Lockton,

while the inferior beds ascend without it to Saltergate Brow. The same thing is observed in some of the hills to the north and west of Helmsley. On the south side of the vale of Pickering too, on the west side of the Derwent, the oolite is soon discontinued, while the inferior beds extend towards the vale of York. Even on the inner slope of the limestone hills, where they descend into the vale, the oolite is frequently discontinued, instead of coming down to the plain; as we see at Wilton, Ebberston, and other places, between Thornton and Snainton. In such places, the gentle southern slope of the hills, just before it arrives at the plain, is suddenly changed to a steep declivity, like that of their northern fronts; and the oolite is broken off at the brow of the declivity, while the inferior beds occupy the rest of the slope. Here, however, as in the northern fronts, the steep descent is smoothed with alluvium; so that the strata are for the most part concealed, though the edges of the harder beds in the series occasionally crop out.

It would be vain to attempt a minute description of all the beds in this division of our strata; for the series is by no means the same in every part where it occurs. Beds that are found in some parts, belonging to this series, are wanting in others; and beds which in some parts are separated by thin layers of sand or marl, are seen in other parts running into one, without any seam or parting. All, therefore, that can be expected here, is a general description of the strata, with a more detailed account of some of the most remarkable beds.

In a few of the beds we find traces of the oolitic structure; and this is particularly the case with the bed of *blue and grey limestone*, which generally occurs immediately under the oolite. This bed, which is often of considerable thickness, may be seen at Pickering, at Sinnington, at Kirkby Moorside, at a quarry on the side of the York road, a little to the south of Malton, and at a number of other

quarries and openings, near Castle Howard and in other places. In some instances, particularly at the Malton quarry now mentioned, the oolite seems to pass into the blue limestone; the latter retaining something of the oolitic structure, but with the *ova* or globules few in number, and frequently of an unusual size, approaching to that of small peas. These large ova, when broken across, present the appearance of concentric circles, with a minute hole in the centre; but this hole, where the fracture is recent, is generally filled with a fine powder. The blue limestone is clouded or intermixed with a grey stone, which may be called sandy limestone; though, from its arenaceous quality, it may perhaps be more properly termed calcareous sandstone. There are large ova thinly scattered in this stone, as well as in the blue limestone; and it is observable, that the colour of the ova changes with that of the stone, with this difference, that in the blue stone the ova are of a darker blue than their matrix, whereas in the grey the ova are of a much lighter colour than the stone, being of a dull or yellowish white.

In other instances, this limestone occurs without any mixture of ova; and it is often of a very fine grain, the fragments presenting a smooth surface, with no vestige of sand. Some of this limestone may be seen at Pickering. It also occurs in quarries near Castle Howard, a little to the north-west of Whitwell; and on the long narrow ridge on which Dalby stands, not far from that hamlet; at both which places it is burnt for lime. The prevailing colour of the limestone is light blue; but it is more or less clouded with light grey, with sometimes a yellowish or ferruginous tinge.

At the last mentioned places, it is uncertain whether the blue limestone can be said to be next the oolite or not, the latter being entirely wanting; yet the limestone corresponds with that which immediately succeeds the oolite at Pickering and Sinnington; besides, the blue limestone near Castle Howard is in the vicinity of the oolite, and may be presumed to run beneath it.

In some places, however, we find a bed of blue and grey limestone under the oolite, not immediately succeeding it, but with some other strata interposed. This is the case at Filey Bridge, where the rocks *(e)* form the series under the oolite; which, as was observed, is there wanting. The uppermost beds, several feet in thickness, consist of calcareous sandstone; and beneath these is a bed of blue limestone, clouded with grey; bearing a strong resemblance to what is found in the Malton quarry mentioned above. It has not the oolitic structure; but it presents the same clouded mixture of blue and yellowish grey stone, and the latter, as at Malton, is more sandy than the blue part of the bed. It may be supposed, indeed, that at Filey Bridge, the beds immediately under the oolite have disappeared along with it, and that this bed has no correspondence with those already described, but belongs to another part of the series. On this subject we remark, that whatever beds may have shared the fate of the oolite at Filey, there appears to be no other bed in the series to which this clouded stratum bears any analogy, except that with which we are classing it.

Among the varieties of this member of the series may be placed the limestone of Hildenley, between Malton and Castle Howard. It differs, however, from all the limestones now described, in the whiteness and uniformity of its colour, which is that of light coloured marl; and, being at the same time compact and uniform in its composition, it is excellently adapted for architectural ornaments, to which use it is chiefly appropriated. It is much softer than the fine grained blue and grey limestone on the south-west side of Castle Howard, and has a much more dull and marly fracture: but it bears a strong resemblance to the grey part of the corresponding bed at Pickering, at least to some specimens of it.

These strata do not abound with organic remains. In some varieties, particularly the Hildenley and fine grained limestone, there

are scarcely any. A few shells, however, occur here and there, in almost all the beds of this series; and in some of them the number is considerable.

There are some parts of the oolite hills where no bed has been discovered analogous to the blue and grey limestone. It is not found in Rowlston scar and Whitestone cliff: nor does it exist in Wass bank, unless we suppose it to be represented there by a bed of whitish sandy limestone, having a faint resemblance to the Hildenley stone. The authors did not observe it in the channel of the stream at Kirkdale church, nor at any place to the westward of that spot; though it is found at Kirkby Moorside.

The next remarkable bed in this series is one that consists of *calcareous sandstone with yellow marl.* This bed, which is often two or three yards or more in thickness, generally occurs a little below the oolite. It may be seen at Nawton, where the road between Helmsley and Kirkdale is cut through it, the oolite being there wanting. It forms a conspicuous feature in the upper part of Rowlston scar. We find it at Dalby; at Terrington; in a bank on the side of the road between Terrington and Castle Howard; on the side of the road from Malton to Whitwell, near Cramb bridge; and in descending the bank leading to Kirkham bridge, near Whitwell; in which place the oolite is seen at the top of the bank, a little above it. Many other localities might be pointed out; but it will be sufficient to add, that it is found in the Filey rocks, under the blue and grey stone, and may be seen in most of the northern fronts of the oolite hills, as in Silphoue moor, in the slope fronting to Harwood Dale. In some of these places we see only one bed; in others two or more beds, with other strata interposed.

This species of rock exhibits a curious compound, the yellow marl, which is often sandy, being distributed throughout the sandstone in numerous irregular patches of all sizes and forms; and these

are usually so abundant, that when the marl is dislodged from the cavities in the stone, the latter presents a singularly cavernous appearance, like the *scoriæ* from a volcano, or the slag from a furnace, though on a far larger scale. At Rowlston scar, in particular, where the winds and rains carry off the marl as soon as it is exposed, the face of the bed appears as if excavated into small grottos, caverns, openings, and sinuosities of all descriptions; while the solid parts of the rock are left projecting in an equal variety of forms, sometimes in sharp points or knobs, sometimes in crooked ridges or lines, resembling the roots or stalks of some shrubs. The rock itself varies in quality, being in some parts very hard, in others softer; in some so calcareous as to deserve to be called limestone, in others a true sandstone. The variety is increased in some places by a mixture of ironstone; and the oxide of iron serves, in many instances, to deepen the colour of the marl.

In several parts of these beds, the marl seems to have resulted from the decomposition of limestone nodules; for such nodules, or *nuclei*, are often found imbedded in the rock; instances of which occur at Rowlston scar. In other places, however, as at Nawton, and near Whitwell, it is far too abundant to be attributed to such a cause. Indeed, the yellow marl, in some of the spots alluded to, seems almost to form an independent bed, the proportion of sandstone intermixed with it being very small. Thin beds or seams of this sandy marl do actually exist in an independent state, between some of the strata in Rowlston scar; but they are much lower than the cavernous bed now described.

In that part of the Filey rocks which corresponds with this bed, the marl is found in smaller quantity; partly in thin seams or sinuosities, partly disseminated through the stone in small crevices, and giving it a yellow tinge when recently broken. The rock also, as at Rowlston scar, is of very different degrees of hardness; and hence,

what has been effected by the winds and rains at the one place, has been accomplished by the waves at the other; for the strata running into the sea, and forming Filey Bridge, present a surface so rugged that it is difficult to walk on it; the soft and marly parts being washed away, while the harder parts, forming a kind of *septa* between them, constitute a labyrinth of sharp knobs and ridges, in countless numbers and endless diversity. The hardness of this rock is increased by its numerous petrifactions, the stone being usually indurated wherever they are imbedded. This circumstance, however, is not peculiar to the petrifactions of Filey Bridge; for the same effect is often produced by those of the chalk, the shale, and other rocks; especially when they contain a portion of iron, either in the form of oxide or of pyrites.

While we are speaking of the Filey Bridge rocks, it may be proper to notice, that their dipping rapidly towards the south, while they also descend into the sea towards the east, may be regarded as corroborating the idea, that a great dislocation of the strata has occurred at Filey bay, occasioning the disappearance of the oolite, and perhaps of some other beds. The greatness of the dislocation may be inferred, from the distance between the Filey rocks and the Speeton shale, viewed in connection with the rapidity of the dip; the intermediate space, now occupied with alluvium, being not only sufficient to contain the thickest part of the oolite itself, but more than sufficient to comprise the whole thickness of the oolite hills, at their greatest elevation.

Respecting the other beds in this series, it is unnecessary to say much. They vary exceedingly in number and quality. To the south and west of Malton, they appear to be extremely few and thin, nay in some places they may be said to be wanting altogether; the shale that succeeds them being only a very little below the oolite. Thus we find the shale close to the blue and grey limestone, at the quarry

near Malton already mentioned. In the bank near Whitwell, on the road that descends to Kirkham bridge, the oolite is at the top of the declivity, the sandstone with yellow marl a little way down, and the shale presently succeeding. In like manner, in proceeding from Castle Howard park to Terrington, we find the oolite succeeded by the blue limestone, and that by the sandstone and yellow marl; a little below, in the valley on the east side of Terrington, we find the shale; and in ascending to Terrington, we again discover the sandstone and marl, lying immediately over the shale; or if any beds are interposed, they must be extremely thin. At Filey, on the contrary, the thickness of the series is considerable, and the beds are numerous; yet their number is much greater at Wass bank and Rowlston scar; at which places, as well as at Whitestone cliff, the thickness of the series, without the oolite, may be estimated at about 200 feet.

In these strata, it is common to find sandstone and limestone alternating: yet, generally speaking, the calcareous matter diminishes, and the sandy matter increases, towards the lower part of the series In Rowlston scar, one of the lowest accessible beds is a sandstone, mixed with yellow marl, similar to that at the top of the precipice, and containing a number of petrified shells. Below it is a thin bed of sandy marl, with shells imbedded in it, not in a petrified state, but merely preserved. Among the more calcareous beds, is a hard limestone, of a dull brown colour, or brownish yellow; which, when recently broken, presents a granular texture, and a glimmering lustre; numerous small crystals, chiefly oblong, appearing in the fracture. In Wass bank are some calcareous beds more highly crystalline, and very hard. One of these beds is of an ash grey colour, and there are two others of a lighter hue. They are very compact; and the thin edges of their fragments are translucent.

Though Whitestone cliff, Rowlston scar, and Wass bank are at a short distance from one another, particularly the two former,

each of them presents a different view of the series. The beds at Wass bank are, generally speaking, harder, and lighter coloured, than those at Rowlston scar; containing little or nothing of the yellow marl, which abounds in the latter place. At Whitestone cliff, the beds are also hard, and contain little of the marl; and here the upper part of the cliff, instead of being composed of a succession of beds, as at the other two places, forms one immense bed, which in some places is about eighty feet in thickness, if not more. This massive bed, like the chalk, has a tendency to split vertically; and large columnar fragments are successively detached from its perpendicular face. Many of these fragments have fallen down into Gormire, a small lake at the foot of the cliff; while many others are lying in ruins on the slope that forms its bank. In some places, the heap of detached materials covers a great part of the front of the cliff; and here some columnar masses of vast size may be seen. One block, which the authors observed, might be about eighty or ninety feet long, forty or fifty broad, and twelve thick. At the top of the precipice stands a huge wall of the same rock, already parted from the rest of the bed by a deep longitudinal chasm, and threatening ere long to fall headlong into the valley, over which it now frowns.

After stating these facts, it is scarcely necessary to add, that this bed is remarkably hard and compact. It is siliceous, as well as calcareous; yet it is most proper to call it a limestone. Its general colour is ash grey; its structure partly oolitic, partly granular or coarsely crystalline, with a mixture of dull earthy matter. Its imperfectly oolitic structure, which it may derive from its immediately following the oolite, may entitle it to rank with the blue and grey limestone, some varieties of which it resembles in colour; but in other respects, especially in its crystalline structure, it differs considerably from all the varieties of that rock elsewhere observed.

Many of the beds in this series, instead of resembling this solid stratum, are schistose. This has been noticed in speaking of the channel of the stream near Kirkdale church. These schistose strata appear most numerous in some of the northern fronts of the oolite hills; as in the hill at Newton, and in Saltergate Brow; where the series differs greatly from that observed in the west fronts of the Hambleton hills. The northern fronts of the oolite hills are, however, so smoothed by alluvium, that they present few places where the beds can be properly examined.

The strata now described are succeeded by what we may term

THE SECOND SHALE.

This member of our strata (marked *f* in the Section) may be seen a little to the north of Filey Bridge, rising from under the series last described. It gradually ascends, as we proceed northward, till, in the cliffs opposite Gristhorp, it attains a great height; the sandstone that caps it becoming thinner and thinner, till it wears out altogether, leaving the shale to occupy the whole front of the cliffs, for a considerable space. It continues to maintain its ascendency as far as Cayton mill, where it begins to be covered up by broken strata that will be afterwards mentioned. In some places, nearly opposite Gristhorp, the fragments or masses, which have fallen from the cliffs, have formed an outwork, to protect them from the violence of the waves.

This shale may be seen in various places round the vale of Pickering. It is found at Wilton, at the foot of the slope occupied by the calcareous series of beds. At Ebberston it has been bored into to a great depth, in a fruitless search for coal. We find it at Hutton-in-the-Hole, where it forms the banks of the beck. It is also seen on the side of the road near Keldholm. At Malton it is found in the

channel of the Derwent; at least on its western bank, where the Malton spaw rises from it. We have already noticed, that it is seen at the quarry on the south side of Malton, and in the bank opposite Kirkham priory. At the latter place it rises to a great height, the strata on the right bank of the river, as was observed, being higher than on the left bank. The shale, however, is also found on the east bank, and it has been bored into at Firby, to the depth of 70 yards, in another fruitless attempt to find coal.

We have already remarked, that this shale occurs in the valley on the east side of Terrington; and to this we may add the valley on the east side of Dalby. At Wass bank, the blue shale is the lowest visible bed, and is found to rise about 100 feet, above the plain where Byland abbey is situated. At Whitestone cliff also, the shale occupies the lower part of the precipice, and a large portion of the slope on the north side of Gormire. It might also be expected at the foot of Rowlston scar; but there it is covered by the alluvium which lies between that precipitous cliff and Hood hill; a small detached hill, resembling a hay-stack, serving, with some other smaller elevations, to connect the Hambleton hills with the plain of Thirsk.

In the smooth northern fronts of the oolite hills, on the north side of the vale of Pickering, the shale does not make its appearance; for in these fronts the hard beds only protrude through the alluvium. It is, however, more than probable, that were the strata there exposed, we should find, instead of a thick bed of shale, a number of thin beds, parted by seams or beds of schistose sandstone. Indeed it is probable, that a great part of what we find in the form of shale, on the south side of these hills, passes into schistose sandstone, before arriving at the northern fronts; for that kind of sandstone is found there in abundance, alternating with numerous beds of shale. Of this we see an instance, in descending from Newton into Newton Dale; where such alternate beds of shale and sandstone appear to occupy

the place of the second shale. Similar indications of the same transition may be seen in several other spots. The shale is generally divided by thin seams of sandstone; and this transition takes place, by the enlargement of these seams into thick beds, and the consequent contraction of the shale beds, which in their turn become thin seams between the beds of sandstone, nay, are sometimes thrust out altogether, leaving the sandstone to fill up their place.

This change, which is very common in the lower beds of shale, may be traced on the coast in this second shale. At a point a little to the east of Cayton mill, the seams of sandstone, interstratified with the shale, are enlarged; particularly two seams or beds, which at some distance beyond that point are separated by a thick bed of shale, but at the point come together, the upper bed descending to meet the lower, while the shale is compressed to a thin edge between them. On the west side of the point, the two sandstone beds again separate, and the shale between them resumes its former dimensions; but its progress, with that of the other shale beds above and below, is suddenly checked at Cayton mill; an interruption occasioned, not only by the wearing out of the upper part of the strata, at the cleft or ravine that leads down to the mill; but especially by a slip in the strata, at least in the higher strata, which with the alluvial beds have come down on the north-west side of the mill, and removed or covered up the shale from thence to Scarborough.

The slip in Cayton cliffs is of a class not uncommon along the coast. The lower strata have not sunk with the upper, but the latter have come down in a mass over the former; and while most of the shale has been pressed out from under the mass, and washed away by the sea, the sandstone beds, corresponding with those which cap the shale opposite Gristhorp, have come down to the beach, occupying the place of the shale that is gone, and covering what has been left. Portions of the shale are still visible here and there, through openings

in the sandstone beds; the latter, as might be expected, being much broken and dislocated. On examining the ground above Cayton mill, and from thence in the direction of Scarborough, we see where the longitudinal fissure has taken place. The surface of the part that has slipped down forms an extensive platform, containing many acres of pasture ground, while the front of the solid strata from whence it has descended, appears as a lofty cliff beyond it. Here the beds, from which the sandstone in the sea cliffs below has been separated, may be seen in their proper place. They correspond, as was intimated, with the lower beds of the Filey Bridge series; which, though they appear to run out in the top of the cliff to the east of Cayton, are no doubt continuous in the interior. The sandstone is chiefly siliceous, and contains, in many places, imbedded fragments of charcoal. In this respect it corresponds with several of the lower beds of sandstone in this district; with some of which it also agrees, in the irregular appearance assumed by many parts of the beds, which instead of being parted by horizontal seams, are traversed by diagonal or irregular lines, dividing the stone into wedge-shaped blocks, and amorphous masses of various forms.

It will be proper to observe, that the surface of the ground that has sunk, is in some places lower behind than in front; and, as these low places are receptacles for water, we find there some pools and marshes; a phenomenon very common wherever any recent slip has taken place. About twenty years ago, a large portion of a hill near Kirkby Knowle, in the skirts of the Hambleton hills, slipped down into the valley; and, the surface of the detached part being lower behind than in the front, a pool of water has been formed in the hollow.

In tracing the strata between Cayton and Scarborough, we soon meet with another derangement, probably of a much more ancient date than the Cayton slip; for, between the White Nab and the Spaw,

the stratified rocks disappear altogether, their place being occupied by the alluvial cliffs formerly mentioned, in speaking of the celebrated Scarborough springs. The alluvial beds continue till we arrive at the lofty promontory where Scarborough castle rears its venerable head. There, on the east and north sides of the hill, we find a thick bed of shale, which appears to correspond with the Gristhorp shale, while the beds above it correspond with the Filey rocks, or rather with the series of beds at Rowlston scar.

As the strata at Scarborough castle present an epitome of the contents of the oolite hills, it may be proper to notice them more particularly. The following sketch of these strata, as observed on the north and north-east, will be found tolerably correct.

1. Some beds of whitish or light grey limestone, generally thin. Among these is a portion of the oolite, of a fine grain, the ova being minute. These beds may occupy 20 or 30 feet.

2. A thick bed of argillo-calcareous sandstone, with large nodules of limestone, and cavities filled with yellow marl. This bed, which may be from 6 to 10 feet in thickness, corresponds with the marly sandstone of Rowlston scar, Nawton, &c. Like that, it is hollowed into cavities, and sinuosities, resembling grotto work; as may be seen in the upper part of the castle rocks, fronting the sea eastward. The hard nodules are generally of an oval shape, with their longest diameter parallel to the plane of the strata in which they are imbedded.

3. Beds of grey limestone, or calcareous sandstone; some of them of a texture approaching to crystalline. In the fissures of these beds, and of No. 2, are many beautiful crystals of calc spar. These beds occupy from 15 to 20 feet.

4. A compact bed of blueish limestone, 6 feet thick, or upwards. This bed may correspond with the blue and grey limestone of this series; though, as in the instance noticed in describing the Filey

Bridge rocks, it does not follow the oolite immediately, but with some other beds intervening.*

5. Several beds of calcareous sandstone, or sandy limestone; from 12 to 15 feet.

6. Shale, alternating with thin beds of sandstone; from 20 to 30 feet.

7. Shale; about 50 feet.

Below the shale is the hard bed which is the next member of the series, occupying the foot of the cliff, and forming a strong barrier, to defend the whole from the fury of the ocean.

The beds No. 6, as well as No. 7, may be considered as belonging to the second shale; in which, as has been observed, there are frequently beds of schistose sandstone. Indeed, the upper part of the shale is found in some instances, to alternate with the lower beds of the series above it; as we see in the bank opposite Kirkham priory, where a bed of the shale occurs even above the marly sandstone.

It will be seen, in the preceding sketch of the strata at Scarborough castle, that there is no bed there over the shale, corresponding exactly with the siliceous sandstone on the shore near Cayton; but it is well known, that the sandstone beds vary exceedingly. Besides, in proceeding from Scarborough castle to the north-west, we soon meet with siliceous sandstone over the shale, similar to the sandstone of the White Nab.

It is scarcely necessary to add, that the thickness of the beds, stated above, is not given from actual admeasurement; but is merely intended to furnish some idea of the relative proportions of the beds. The whole height of the rock is said to be about 300 feet.

* A mistake has been inadvertently made in page 74, in mentioning the localities of this limestone; it being there intimated, that it does not occur at Kirkdale church. The authors did not find it in the channel of the stream, opposite and above the church; that being occupied by thin beds of calcareous sandstone, as stated in page 69: but they met with it in a higher position at the ford below, and at a quarry on the north-west side of the church.

While speaking of this lofty promontory, it may be proper to remark, that it has been supposed to be vastly diminished since the close of the twelfth century; as its superficial extent is estimated by William of Newburgh at *sixty* acres, whereas it is now less than *twenty* acres. But if we consider, that Leland, who wrote little more than 300 years after William of Newburgh, and about 300 years before the present time, states the extent to be *sixteen* acres; we cannot doubt, that there is a mistake in the text of William of Newburgh, the word *sexaginta (sixty)* having been substituted for *sexdecim (sixteen)*; and consequently, that the area occupied by the castle is nearly the same now, as it was six centuries ago, the ancient acres being larger than the modern.* In further confirmation of this, we need only refer to a document drawn up in the 14th. of Edward III, by which it appears, that at that era, not more than 150 years after the time of William of Newburgh, the pasture ground in the area of the castle was reckoned only *fifteen* acres.† Indeed, that historian's own description of the place corresponds so exactly with present appearances, as to preclude the idea, that these rocks have undergone any material change during the last six centuries.—These observations, it is hoped, will not be deemed superfluous, as they may serve to correct the erroneous notions which some have advanced, concerning the rapidity with which our rocky shores are dilapidated.

In proceeding along the shore, north-west from Scarborough, we find the continuation of the second shale; but the beds are generally much thinner than in the east front of the castle rocks, and the calcareous series above the shale is discontinued; a bed or two of sandstone, chiefly siliceous, being all that we find over the shale, except the alluvial covering. The latter, indeed, in some places comes down

* See History of Whitby and the Vicinity, II. p. 738. Note.

† See the document in Hinderwell's History of Scarborough (8vo.) p. 53, 54.

to the very beach; the sandstone, and even the shale, being interrupted, or covered. The beds of shale are usually of no great thickness, and are interstratified with beds or seams of schistose sandstone: but in a few places, particularly in a small bay, or wyke, opposite Burniston, it resumes something of its former importance, occupying the face of a considerable cliff.

It is rather singular, that at Cayton, at Scarborough, at Burniston wyke, and to within a little of Cloughton wyke, the shale beds are nearly on the same level; for, instead of going out at the top, or sinking entirely below the sea, they merely rise and fall, in an undulating line. These undulations are very numerous between Scarborough and Cloughton wyke. The shale descends below the beach at Peaseholm beck, and rises again beyond it; disappears another time at Scalby mill, but resumes its place on the further side; and in like manner rises and falls repeatedly, in its progress northward. It is scarcely necessary to add, that the other strata, in these places, are subject to the same undulations.

The transition of this shale into sandstone, as it advances towards the north, has already been noticed. We have a full display of it before we arrive at Cloughton wyke: for, a little to the north of Burniston wyke, one of the sandstone beds in the shale is enlarged to the thickness of 15 or 20 feet, while the shale is proportionally diminished; and though the shale, a little after, regains a portion of its extent, it presently loses ground, and dwindles into an insignificant seam, scarcely discernible, while the sandstone swells into immense beds, forming a lofty precipitous cliff as far as to Cloughton wyke. Here the shale again shews itself, below the sandstone, though the latter greatly predominates; but both run out at the back part of the wyke, the upper strata being there interrupted.

It is unnecessary to trace the further progress of this second shale; for though something corresponding with it may be found

among the strata in Stainton Dale cliffs, and other places, it is so much of a piece with the other numerous shale beds, alternating with the sandstone in a lower part of the strata, that it can scarcely be identified; except where we can distinctly observe the beds that immediately succeed it.

This shale, which occupies so large a space in our strata, is far from being uniform in its qualities. In many places, it differs little from the upper shale; containing a large proportion of clay, with a mixture of calcareous matter. In others, it is sandy and micaceous; and indeed there are few places where we do not find in it small shining specks of mica. Its general colour is a blueish grey; sometimes very light, sometimes so dark as to appear almost black, but commonly of an intermediate hue. In some places too, it is of a dull ash grey or dusky colour, especially where it partakes very largely of clay, as in some of the lower parts of the Gristhorp cliffs. In a part of the slope below Whitestone cliff, a little above a free-stone quarry, we find some greenish shale, which seems to be the lower part of the same shale that appears in the front of the cliff. The shale is generally most sandy, where it is about to pass into sandstone, and where it contains most sandstone beds; and yet at the point east from Cayton mill, where, as was stated, the sandstone thickens, and the shale is compressed, the compressed bed is so highly argillaceous, that we find on its surface an efflorescence of sulphate of alumine, or native alum, as well as some sulphate of iron. The same phenomenon may be seen in a few other spots, particularly near the White Nab, on the other side of Cayton, where a portion of the shale is uncovered.

The sulphur in these native preparations is derived from the decomposition of pyrites, which is found in several parts of this shale; sometimes in clusters of elegant crystals, like those in the lower chalk. Oxide of iron is also very common in many parts of the

shale, appearing in ferruginous veins and patches; as may be seen in Whitestone cliff, and at Scarborough castle. Calcareous minerals, particularly selenite and gypsum, are also not uncommon in these beds. Numerous crystals of selenite occur in the Gristhorp cliffs, especially where the schist is most argillaceous. Thin veins of fibrous gypsum traverse the shale in various places; of which instances are seen at Scarborough castle. Some of the specimens have a pearly lustre.

Organic remains are not so abundant in these strata as in the upper shale: yet in some places, particularly in the dark coloured clay at Gristhorp, they are numerous. They consist principally of shells, with some fragments of wood. The sandstone that alternates with the shale partakes of its petrifactions. It contains pieces of wood, sometimes of a considerable size, as well as fragments of charcoal: and the beds of this kind between Cayton mill and Scarborough, mentioned above, may be considered as belonging to this class, more than to the sandstone of the upper series; though, where the strata are so much broken, there must be a mixture of both.

As this sandstone partakes of the schistose quality of the beds which it attends, so it is also somewhat assimilated to them in colour; yet where it begins to predominate over the shale, it lays aside both; growing solid and massive in its structure, and whitish or yellowish white in its colour. This is especially the case in the precipitous cliffs to the south-east of Cloughton wyke, where, as was said above, the shale is wholly overpowered, and the sandstone becomes independent.

The second shale being one of the lowest beds of the oolite hills, it may be proper to make a remark or two more, relating to these hills, before we proceed to the next member of the strata.

At the out-skirts of this range, we often meet with small insulated hills, detached from the main body. Hood hill and other appendages to the Hambleton hills have already been noticed. Some hills of the same form, but of a larger size, may be seen at Hawnby,

towards the lower end of Bilsdale. Similar insulated elevations are found between Silphoue moor and Saltergate, the most remarkable of which are Langdale End and Blakey Topping. These hills are not round, but oblong, like hay-stacks. They have flat summits, and smooth sloping sides, corresponding with the fronts of that range from which they are detached.

Having mentioned Blakey Topping, it may be proper to notice here some singular rocks, that run along the margin of a deep ravine, about two miles south from that hill. These rocks, some of which are here represented, are denominated

THE BRIDE STONES.

These rocks belong to the series above the second shale, and are somewhat analogous to the marly sandstone at the top of Rowlston scar, though they are much more siliceous. They appear in strata of great thickness, of a yellowish white or grey colour; and being of very unequal hardness, the soft parts, which are nearly in the state of loose sand, and are chiefly in the lower part of the beds, have been carried off by the action of the rains and the atmosphere, forming large caverns and recesses, while the harder parts remain as roofs and

pillars. The Bride Stones are the highest rocks in the spot which they occupy, which however is lower than the adjacent Saltergate moor. They are rendered conspicuous by their frequently protruding above the alluvium; and some portions of them are found insulated, in various fantastic forms. The most singular of the whole group is that represented in the centre of the annexed sketch, in the form of a mushroom, with a slender stalk. It is about 30 feet high, and 20 broad near the top, in one direction; while the stalk or pillar, that supports it, is only 3 feet across in one direction, and about 7 in the other.

We have had occasion to notice, that the second shale, in a few places, alternates with the lower beds of the series above it; and we have also to remark, that, in some instances, it interferes in a similar way with the beds that succeed it.—These beds consist of

IRONSTONE AND SANDSTONE.

Under this head are comprehended some strata, which, like those succeeding the oolite, cannot be very easily defined; they differ so greatly in different places. At the foot of Gristhorp cliffs, where they first make their appearance, they form a large series, to which there is nothing exactly corresponding, in any other place where their progress has been investigated. The whole beds occurring there, including the shale and sandstone in the cliffs, belonging to the foregoing member of the strata, as observed at low water in a small bay or indentation of the shore, are as follows:

1. A lofty bed of shale, rising towards the top of the cliff, and there meeting the alluvium.
2. A bed of grey sandstone, nearly of the colour of the shale.
3. A thick bed of shale, occupying the lower part of the cliff.
4. Whitish sandstone, of considerable thickness, appearing at the very foot of the cliff.

N. B. The beds, No. 2 and 4, are those which meet each other at the point on the east side of Cayton mill, as mentioned in p. 81, and No. 3 is the shale bed that is compressed between them.

These four beds belong to the second shale, which may also appropriate to itself a part of the following, especially as portions of the shale are found among them.

5. Shale, sandstone, and ironstone, forming the foundation of the highest part of the beach, and so much concealed by sand and gravel, as not to admit of a more particular description.

6. Soft white sandstone.

7. Light blue shale, with some ironstone in nodules.

8. Soft whitish sandstone, like No. 6.

9. Compact grey sandstone.

10. Shale, with ironstone nodules.

11. Schistose sandstone.

12. Shale, with ironstone nodules, like No. 10.

13. Soft blueish sandstone.

14. Shale.

15. Soft sandstone.

16. Hard sandstone, partly ferruginous, being red externally, and blueish in the recent fracture.

17. Lowest visible bed of shale.

18. Various beds of reddish yellow sandstone.

19. Thick bed of calcareous sandstone, or siliceous limestone, very hard and compact.

All these beds, from No. 5 downwards, have a dip towards the cliff; so that their edges are exposed one after another, as the tide retires. No. 19, which is the lowest, is also the thickest, and one of the most remarkable. It resembles in structure the immense bed in Whitestone cliff, being partly oolitic, and partly granular, with numerous small crystals, many of which are oblong. The ova are few

and large, with a mixture of what appear to be small fragments of shells; and the stone is coarser grained than that of Whitestone cliff, as well as more opaque, the edges of its fragments being scarcely translucent. Its colour is grey, but of various shades; being in some parts ash grey, in some reddish, and in some approaching to yellow. When struck with the hammer, it emits a ringing sound: which is very perceptible even in fragments of the stone. Like the Whitestone bed, it splits vertically, and is thus parted into huge blocks, often separated by considerable fissures, into which the waves are driven at low water, with a hollow murmuring noise.

The ironstone, which holds a conspicuous place in this series, is extremely hard and compact. It is red or ferruginous without, and blue or iron grey in the recent fracture. It appears to be partly calcareous, partly argillaceous, and has been ascertained to yield 15 per cent. of iron; being collected for an iron foundery at Newcastle, and conveyed thither to be smelted. The beds are seldom more than 9 or 10 inches thick; and more frequently consist of nodules, or flat intersected masses, than continuous strata. The ironstone is generally imbedded in shale, which fills up the interstices between the nodules or blocks; but sometimes it is found disposed as a crust on the surface of a sandstone bed, the intervals in that case being filled up with sandstone. The shale beds, in some places, are rather bituminous. Shells and pieces of petrified wood are occasionally found in the ironstone, as well as in some of the sandstone beds.

These strata (marked *g*) form what we may call the pavement of the shore, not only in front of Gristhorp cliffs, but from thence, with some interruptions, and various changes, as far as to Cloughton wyke. The interruptions are more apparent than real, and ought rather to be called depressions; for these beds undergo in their progress northward, those undulations already noticed in speaking of the second shale; nay, the undulations are more striking in them than in

the shale, from their position, and their superior hardness. From the small bay noticed above, where the series is so extensive, the beds rise towards Cayton point, so often mentioned. In the bay opposite the mill, they are somewhat depressed and broken; and, after undergoing some lesser undulations and disturbances, between that and the White Nab, they rise towards that point; but are soon after depressed more than ever, in the bay opposite Scarborough, the harbour being formed in this depression, or apparent interruption. Part of the depressed strata might formerly be seen between the Spaw and the piers, being the rocks called Ramsdale scar; but these rocks were removed, to improve the harbour. Immediately beyond the harbour, the hard strata rise again, rather abruptly, at the foot of the castle, the piers being probably founded on part of them. A strong barrier of ironstone and sandstone defends the foot of the castle rocks on the east; rising towards the shale, and constituting the foundation on which it rests. Opposite the bay on the north side of the castle, the hard strata again sink down; but they rise again in greater extent on the further side of it: and thus they continue to fall and rise, in frequent and striking undulations, to within a little of Cloughton wyke.

The elevated points, between the depressed parts of the strata, invariably project forward, while in the intermediate space the cliff retires backward, forming a succession of bays, or recesses. The reason of this is sufficiently obvious, on a bare inspection of these projecting points; for we find the rocks there so consolidated as to present a powerful resistance to the attacks of the ocean, whereas the intermediate parts of the cliff are far more vulnerable. In the bottoms of the bays, the shale usually predominates; but at the points, it is commonly excluded by the sandstone and ironstone; insulated masses of which often stand like pillars in front of these points, marking out their extent at former periods, and defending them from the rude shocks of the stormy sea. Examples to illustrate these remarks, may

be seen at Cayton point, and other *nabs* to the south of Scarborough; and still more on the north, between Peaseholm beck and Cloughton wyke.

These successive elevations and depressions are also attended with another phenomenon,— the frequent derangement of the strata, particularly towards the bottoms of the recesses on the shore. There the upper strata, as well as the lower, are often deranged; nay, in several instances the upper beds are wholly interrupted or broken off. This is the case at Cayton mill, and still more at Scarborough sands; as also at Peaseholm beck, Scalby mill, and other places to the north of the town; where the alluvium comes down to the beach.

From these facts, and the general appearance of this part of the shore, we may presume, that not only the strata which have slipped down between Cayton mill and Scarborough, but the other rocks along a great part of the coast, have at some distant era occupied a much more elevated place, from whence they have sunk down to their present broken, undulating, and irregular position. This idea is corroborated, by the low and compressed state of the strata at Scarborough castle, compared with that of the corresponding strata of Oliver's Mount and Seamer moor; and by the irregular dip of the strata along this shore, which is far from being conformable to that of the strata in the inland hills.

It has been intimated, that the ironstone and sandstone beds, are not only subject to undulations, in their progress northward, but to various other changes. Even at Cayton point, there is a perceptible change, both in the number and qualities of the beds; and it is much more perceptible at the White Nab. Here, however, we still find four beds of ironstone, interstratified with several beds of sandstone. The beds in general appear to be harder than on the Gristhorp shore, and rather more calcareous, containing a greater number of petrified shells. A thick compact bed, apparently corresponding with No. 19

of the Gristhorp series, supplies large and durable blocks of stone for the Scarborough piers. In more than one bed, however, we observe a mixture of the crystalline and oolitic structure.

The very hard rocks, at the foot of the castle on the east side, form the continuation of this series. They consist of grey calcareous sandstone, partly incrusted, partly intermixed, with portions of ironstone; and contain numbers of shells, which, owing to the hardness of the stone, it is very difficult to disengage or break off.

Beyond the north sands, the ironstone and sandstone make a conspicuous figure on the shore. The ironstone frequently covers the sandstone, as a solid crust; and from this ferruginous coating, the rocks in many places appear as if they had passed through the fire: some striking instances of which may be seen beyond Scalby mill. In other places, the ironstone is found in nodules, as on the Gristhorp shore; and a bed of this description is found in the face of the cliff, among the shale, in Burniston wyke.

Before we arrive at Cloughton wyke, the extent of this series is vastly diminished: for at the point on the south-east side of that creek, we find nothing that can well be appropriated to it, except a bed of rough sandstone, partly calcareous, immediately below the shale; and a bed of hard calcareous sandstone, or coarse limestone, incrusted or intermixed with ironstone, and abounding with shells, like the rock at the foot of Scarborough castle. These beds also bear a considerable resemblance to some of the harder strata at Filey Bridge; and it is observable that, at each of these three places, there are some of the same kinds of large shells; though the Filey rocks belong to a higher part of the strata.

The ferruginous beds, having reached the upper end of Cloughton wyke, are discontinued with the strata over them; nor has their progress been traced any further along the shore. In the lofty Stainton Dale cliffs, where the authors examined the whole series of beds with

considerable minuteness, nothing corresponding with this ironstone could be found; though the next member of the strata is there very conspicuous. Nor have the hard beds been fully identified in any of the inland heights, though some resembling them are observed in various spots. A bed of calcareous ironstone, containing shells, very like the ironstone beds at the Gristhorp shore and the White Nab, was found by the authors, on the east side of Newton Dale, north-east from the village of Newton; and, from its position in the strata, this bed may be presumed to be the continuation of the same ironstone; but the beds in Newton Dale, and other inland places, differ so greatly from those on the coast, that it is no easy matter to trace the correspondence between them. The difficulty, in this instance, is increased by the number and variety of the ironstone beds, occurring among the inferior beds of sandstone and shale.

Instead, therefore, of attempting to pursue this member of the strata any further, we pass on to the next, viz.

THE BLUE LIMESTONE.

On reaching this part of our strata, we take our final leave of the oolite hills: for, though several of the beds which are now to be described, are known to run under these hills, and form their basis; yet they hold a conspicuous place in the higher parts of the next range of hills, to which therefore they ought to be appropriated.

The hills belonging to the northern part of our district, from the oolite range to the banks of the Tees, are all of one character: the upper part of them consisting chiefly of sandstone, sandy shale, bituminous shale, and coal; with some limestone and ironstone beds; the lower, which is commonly the principal part, consisting of the great beds of aluminous schistus, and the various seams that are interstratified with them. From the occurrence of coal in these hills, some

would term them *coal measures*, or *coal fields;* but the coal beds which they contain are too inconsiderable to give name to the whole range. If we allot them a particular designation, they ought to be termed *The alum hills;* for the great beds of aluminous schistus form their most distinguishing feature.

The outline of these hills differs greatly from that of the oolite chain. They have, indeed, generally speaking, a gentle declivity towards the south, and abrupt cliffs towards the north; but their summits instead of being flat are rounded, and their exterior or northern faces, instead of being smooth, and forming a regularly inclined plane, are rugged and broken. In many of their northern fronts, we find, not far from their summits, a precipitous or steep cliff, of sandstone; from the foot of which, the shale beds form a declivity more or less gentle, descending to the valley or plain below. Sometimes we find two or more steep cliffs, with gentle slopes in the intermediate spaces; and it is not uncommon to find the slope between two precipices, or steep descents, forming a terrace of great extent, in front of the higher part of the hill, which in that case exhibits the appearance of one hill piled upon another. The lower precipices are sometimes formed of the beds immediately over the alum shale, and sometimes of the hard beds that protrude through it.

The alum hills are of great extent, constituting the principal part of the Eastern Moorlands of Yorkshire. They may be divided into three ridges or chains, running parallel to one another, from east to west; all commencing from the shore on the east, and all terminating in some part of the plain of Cleveland on the west; but differing much in length, breadth, and height; the most southerly being in all these respects the greatest, the middle chain holding the next rank, and the most northerly being the least. The first, which comprises the highest land in our district, commences with the Stainton Dale cliffs, the high promontory called Peak, and the Fyling hills; and terminates

with Arncliff, Osmotherley hill, and Silton hill, on the west. Some of the highest points in this chain are Stoupe Brow hill, Lilhoue cross, Cock Heads, Ralph Cross, Burton Head, Coldmoor, and Cranimoor. Cock Heads and Ralph Cross, are about 1400 feet above the level of the sea, the elevation of Burton Head is 1485 feet, and Coldmoor and Cranimoor are about the same height.

Kildale, Commondale, and the vale of the Esk, divide these hills from the second chain; which, commencing with the west cliffs of Whitby, and those of Kettleness and Runswick, has its western extremities at High Cliff Nab, Rosebury Topping, and the hills that overlook Little Ayton and Easby. Danby beacon, near the centre of this chain, is 966 feet above the sea, and the height of Rosebury, well known for its conical summit, is 1022 feet. High Cliff Nab, and a few other elevated points towards the west end of the chain, may also rise about 1000 feet.

The third and lowest chain, which is also the most narrow and broken, is separated from the foregoing by the vales of Dalehouse, Lofthouse, Skelton, and Guisborough. It begins at the high cliffs of Boulby, and skirting the shore as far as Huntcliff, proceeds from thence along the south side of the fertile plains of Marsk and Kirkleatham, finishing its course at Hambleton End and Bernaldby moor, near Ormesby. The summit of this moor, Eston Nab, has an elevation of 784 feet; that of Boulby or Easington heights, at the other end of the range, is 681 feet; and that of Birdley* moor, beside Upleatham, which is near the centre, is 533 feet.

Of these three chains of hills, the first is about 35 miles long, and from 5 or 6 to 10 or 12 broad; the second is about 18 miles in length, and from 3 or 4 to 7 or 8 in breadth; and the length of the

* The names *Birdley* and *Bernaldby* have been sometimes written improperly *Burleigh* and *Burnaby*. *Burton* Head has in like manner been transformed into *Botton* Head.

third does not exceed 15 miles, while its greatest breadth is only between 2 and 3 miles.

The blue limestone, which we are now to describe, is found only in the first and second of these chains of hills; for in the third, the aluminous schistus comes so near the surface, that several beds occurring in the highest parts of the first two chains, are excluded. The limestone, indeed, is thrust out, in not a few of the hills in the first and second ranges; as will appear from a more particular description of its localities.

Though we speak of this bed as introducing us to the alum hills, we do not mean to intimate, that it is usually the highest rock in these hills, where their upper beds are entire; for there is often a considerable thickness of strata over it: but it is the highest of the rocks discernible on the coast, which we have identified among the upper beds of these hills. When the great height and extent of the first chain of the alum hills are considered, it will not be deemed surprising, that many beds exist in the interior, of which we find no trace on the coast; and on the other hand, that there are some strata on the coast, which have nothing corresponding with them in the interior. It is well known, to all who have attended to the study of geology, that beds which are of a great thickness in one part of the strata, run out into a thin edge, and often entirely disappear, in other parts; and that portions of the strata often change their character, passing from one kind of rock into another. Instances of such disappearance, or transition, have already been noticed, in describing the last three members of our strata.

The beds over the blue limestone, which, where that rock exists, form the upper part of the first range of alum hills, and which descending with their southern slopes, run under the back part of the oolite hills, are different in different places. They consist of shale and sandstone, generally siliceous; and occasionally exhibit a mixture

of ironstone. In some places, as in Harwood Dale, and Newton Dale, particularly the latter, the sandstone beds are very numerous. Among these we find a very hard siliceous bed, approaching to the state of quartz rock. It has obtained the name of *crow-stone;* and, owing to its durability, is the material of which several of our ancient rude monuments, consisting of upright unsculptured stones, have been made.* It is whitish, or greyish white; is very compact and fine grained; its recent fracture shews more of a crystalline aspect than any other siliceous sandstone in the district; and the edges of its splintery fragments are translucent. This kind of stone is not of very general occurrence in these strata: it seems to be most abundant in the upper part of Harwood Dale, where a ledge of this hard rock may be seen projecting over the less durable materials, in the upper part of the cliffs. By its superior durability, it is detected in a similar position, in some parts of Newton Dale, to the north of Newton.

A very thick bed of hard siliceous sandstone, but of a coarser description, may be seen above the limestone, in the summits of some of the lofty hills of this range, fronting the plain of Cleveland. This bed may be seen to most advantage on the brow of a hill at the head of Bilsdale, looking down upon Broughton and Ingleby. Here the bed, for a considerable space, is divested of the alluvial covering, and being split by vertical fissures into vast blocks, often rectangular, presents a singular assemblage of massy pillars, like the ruins of some fabric of Cyclopean masonry. Its resemblance to a work of art was much greater some years ago, when one of these square blocks, lying horizontally on the tops of other two, into which position it had accidentally fallen at some distant period, exhibited the appearance of an arch or door-way. These rocks have been called the *Wain-stones;*

* See an account of some of these stones, in the History of Whitby and the Vicinity, II. p. 664, 665, 666.

perhaps from some fancied resemblance which this arch and the group beside it bore to a *wain*, or waggon, with its team and driver. The place was formerly much resorted to by the neighbouring swains, for their amusement; and numbers of the visitants carved their initials on the stones that formed the arch: but the lintel of the arch having been wantonly broken down some years ago, the group no longer possesses the same interest.* Many enormous masses of this stone have fallen down from their native bed, and are found in various positions a little below.

A thick bed of sandstone, apparently corresponding with the Wain-stones bed, is found in the front of Silton hill. A large mass of this rock, projecting from the face of the bed, and nearly detached from it, has obtained the name of the *Hanging stone*, from its overhanging position; the effect of which is greatly increased by its being perforated behind, the middle part of the bed having been dissolved, while the upper part remains over the aperture, forming a natural arch.

In the front of a hill, about a mile to the south of Godeland chapel, where those singular British remains called the *Killing Pits* † are found, there are similar massive sandstone rocks; but they belong to a higher part of the strata, and are a kind of *crow-stone* beds. Near the same place, a little above Hunt House, occurs a large bed of siliceous sandstone of a singular description, which may be regarded as a variety of the crow-stone. It is composed of fine white quartz crystals, with scarcely any cement or matrix, and having so little cohesion, that the stone is easily crumbled to pieces between the fingers. The sand or powder, resulting from its pulverization, is used by the farmers in sharpening their scythes.

It may be proper to observe, that though we have discovered no rock on the coast corresponding with the crow-stone, the thick

* Ibid. p. 767, 768. † See an account of these remains, Hist. of Whitby, &c. II. p. 670, &c.

sandstone beds that form the precipitous cliffs on the south side of Cloughton wyke, may bear some analogy to the Wain-stones; being nearly at the same distance above the blue limestone. We may add, that, besides the instance noticed as occurring in Newton Dale, there are other spots where ironstone beds, analogous to those of the Gristhorp and Scarborough shores, may be seen among the upper strata of the alum hills. In a bank on the road from Whitby to Scarborough, about a mile and a half south from Flask inn, the road has been made through a bed of sandy shale, containing ironstone nodules, disposed in regular layers. These nodules exhibit a peculiar variety of ironstone, which occurs also at Burniston wyke. Each ball or nodule is usually enveloped with a crust in a half decomposed state, sometimes near an inch in thickness, porous and cellular like some kinds of slag. This crust is of a rusty colour, with a mixture of green specks. The green colour is much more conspicuous in the solid nucleus which it incloses; and which is often of great specific gravity. Some specimens, from their green aspect, bear a great resemblance to copper ore.

Having thus noticed the beds that occur over the blue limestone, let us proceed to examine that rock itself.

The name *blue limestone* is applicable only to the principal part of this member of the strata; for a considerable portion of what must be viewed as belonging to it, is *grey*. Immediately under the hard ferruginous beds, at Cloughton wyke, we find a coarse grey limestone, somewhat sandy; and beneath that a hard, compact, blueish limestone, of a considerable thickness. Both abound with organic remains. These beds (marked *h*) first make their appearance on the inside of the south-east point of the wyke; and rising from thence towards the bottom of the wyke, they are found at a considerable height, immediately beyond the interruption there, in the face of a perpendicular cliff. Here some springs, issuing from the upper part

of the rocks, and much impregnated with calcareous matter, have produced a singular effect on the front of the cliffs. The calcareous deposition has encouraged the growth of moss in the crevices and on the ledges of the rocks; and quantities of that moss being successively incrusted with lime, hang down in curious columns, or stalactites; so that the face of the cliff is adorned with a kind of rude colonnade of mossy pillars, some of which appear as if furnished both with capitals and pedestals.

A little beyond that interesting spot, the limestone beds, with some of the other strata, are interrupted; but we soon recover them in the higher part of the Cloughton cliffs. At Haiburn wyke there is another interruption; but the limestone beds are again continued in the lofty Stainton Dale cliffs; where they rise to a great height, and at last, with the higher sandstone beds, go out at the top, a little to the south of the Peak. Beyond that point, we no more meet with these beds in the sea cliffs; but opposite that part of the shore which skirts Hawsker Bottoms and Gnipe-houe farm, where there is a remarkable depression of the strata, the limestone beds, which had risen to such a great height at Peak, are found not far from the shore, cropping out along the ridge on the east side of Gnipe-houe, and again at a small stream, about half a mile further south, and nearly a mile to the south-east of Hawsker. The beds at these spots dip towards the north or north-west, conformably with the bend of the other strata, with which also they must needs rise again between Gnipe-houe and Whitby, and finally go out at the surface; but their outgoing, which must be a little to the north of High Whitby, is concealed by the alluvium.

In the interior of this first range of the alum hills, these limestone beds make their appearance in various places; though in some of the hills they are entirely concealed. We find them in Harwood Dale, at Dry Heads, about half a mile north from the chapel, and

scarcely two miles from the north front of Silphoue moor, one of the oolite hills. Here the limestone is seen in the south bank of a little stream, running into the principal *beck* that waters this dale, a little above Dry Heads. A bed of coarse shale lies immediately over the limestone, and above that are some thick beds of sandstone, perhaps corresponding with those of the steep cliffs on the south side of Cloughton wyke. The crow-stone beds are found at a greater elevation, chiefly in a higher part of the principal dale. In the east bank of that dale, we find the same series of sandstone, shale, and limestone, immediately below the spot occupied by those rows of circular cavities at the Dry Heads, which mark out the site of an ancient British town.*

The blue limestone has not been observed in Newton Dale. If found there at all, it must be among the very lowest beds. Much calcareous matter, however, exists in some of the higher beds of sandstone, towards the upper extremity of that valley; for a copious spring, issuing not far from the top of the west bank, at a point about two miles north-west from Saltergate, deposits on the bank, in its descent to the beck, immense quantities of calcareous incrustations and stalactites, tinged with a mixture of oxide of iron.

The limestone beds have been discovered, three or four miles to the north of that spot, in the channel of Brockhole beck, which runs into the vale of Godeland, about half a mile below Brockhole beck bridge. There can be no doubt, that they are continued through the heights to the east and north of that place, as they appear on the other side, at Maybecks, on the Sneaton estate: nay, they run, perhaps with some interruptions, to the banks of the Esk, at the northern extremity of Sneaton lordship; for they crop out in two woody ravines, in the valley on the north side of Sneaton. In one of these

* See History of Whitby and the Vicinity, II. p. 671.

spots, the footpath from Whitby to Sneaton crosses the limestone, at a small stream which flows through the ravine into Shalmrigg beck, as does also the stream running through the other ravine, a little to the west.

Towards the western extremity of this chain, the limestone beds are found cropping out near Swainby, in the south-west bank of Scugdale, at a great elevation. Here the limestone is about 15 feet thick; a bed of shale, 12 feet thick, lies immediately over it; and above that the sandstone beds rise to a considerable height. In the front of Coldmoor and of the Wain-stones hill, the blue limestone crops out at a much greater elevation. In the central parts of this range, towards Burton Head and Ralph Cross, it has not been detected; but there can be little doubt of its existing there, concealed by the alluvium; especially as it is found towards the centre of the second chain of alum hills, on the north-east side of Commondale, about two miles to the south-west of Danby or Castleton coal-pits. To what extent the blue limestone is continued in the rest of the second chain, has not been ascertained; but its limits cannot be very extensive, for it is not found in the strata along the shore, and in several of the western hills of this chain, as well as in those of the third chain of alum hills, the aluminous beds rise too near the surface, to admit its existence above them.

As these limestone beds occupy a high position in the alum hills, so we have evidence that they run under the highest of the oolite hills; for they appear in some of the valleys immediately beyond them. This is particularly the case at Sutton-under-Whitestone-cliff, on the north side of Hood hill; where we find in the plain, the same blue limestone that crops out in the fronts of the Cleveland hills, though somewhat different in its qualities. The blue and grey limestone at Coxwold appears to belong to the same beds.

The qualities of this rock, however, are far from being uniform. Sometimes, as at Cloughton wyke, we find a considerable thickness of grey limestone over the blue; in other instances, the grey limestone is found both above and below the blue, and the latter is almost excluded; in others, the blue so far predominates, that the grey is thrust out. Sometimes the one passes into the other, and not unfrequently we meet with a clouded mixture of both; as in the blue and grey limestone under the oolite. The grey is occasionally yellowish, or brownish; but more frequently dusky or ash-coloured. The blue is in some instances very light, or blueish grey; in others, very dark; and in others, it is more properly black than blue. Some parts of the rock, especially in the grey limestone, are sandy and schistose; others are very compact, and highly calcareous. Sometimes the stone abounds with shells; in other instances, it contains few or none. In some specimens, the recent fracture presents a dull, earthy aspect; in others, we see a mixture of small shining crystals; in others, the crystals are more numerous; and in a few, the structure is almost wholly crystalline; in which case, and in some of the other instances, the crystals are usually large and oblong. The most crystalline specimens are not of the darkest colour, some of them being of a light grey: yet, in general, the stone is most compact, where it is of the deepest blue.

We have already seen, that at Cloughton wyke, these limestone beds succeed the ironstone, or ferruginous sandstone; and we have now to remark, that although we do not find the ironstone beds attending the limestone in its progress in the interior, yet we find, in almost every place where the latter occurs, a portion of iron intermixed with it. Ferruginous patches and veins are very common; the blocks of stone often appear incrusted with iron; and the weathered faces of the beds frequently have a rusty aspect, the iron making its appearance where the stone is partially decomposed.

The presence of so much oxide of iron in the rock, is a great impediment to the process of reducing it to lime. In some of the first attempts of this kind, the whole contents of the kiln were run together into one mass, resembling slag. When care is taken, however, to separate the ferruginous crusts, and other parts of the stone where the oxide of iron is most abundant, the blue and more compact parts of the rock produce an excellent lime. The limestone has for some time been quarried and burnt for this purpose, at Sutton-under-Whitestone-cliff, and in Scugdale; and more recently in Commondale, and at Maybecks. At the Maybecks quarries some specimens of rock have been obtained, more highly calcareous than any other found in the district, and scarcely surpassed by any in Britain. The proprietor, James Wilson, Esq., of Sneaton Castle, having procured from the Royal Institution an analysis of some specimens of that limestone, and some other limestones in this district, has favoured the authors with a statement of the result, which may be exhibited in the following table:

	Thornton.	Lockton.	Commondale.		Maybecks.			
			No. 1.	No. 2.	No. 1.	No. 2.	No. 3.	No. 4.
Carbonate of Lime...	37.1	32.3	34.9	33.7	55.6	77.6	98.1	69.
Silex and Alumine...	59.6	63.7	61.	63.4	40.6	18.9	.6	24.3
Oxide of Iron.....	2.5	2.9	3.	2.	2.8	2.5	.8	2.7
Water.....	.8	1.1	1.1	.9	1.	1.	.5	4.
	100.	100.	100.	100.	100.	100.	100.	100.

The relative proportions of silex and alumine, in these specimens, are not stated, except in regard to No. 4 of the Maybecks or Sneaton limestone, which, in the 24.3 parts of silex and alumine, contained in 100 parts of the limestone, was ascertained to yield 16.1 of silex, and 8.2 of alumine. No 3 of the same limestone, is remarkable for its large proportion of carbonate of lime, being no less than 98 parts in 100 parts of the stone. In this specimen there was found a

slight trace of magnesia. It ought to be observed, that this specimen and No. 2 of the Sneaton limestone, and perhaps we may add No. 4, may be considered as choice specimens, superior to most of the blue limestone of our district.

For the sake of comparison, it may be proper here to introduce a table of the analysis of the magnesian limestone of the county of Durham, taken from the account of that limestone, communicated to the Geological Society by N. J. Winch, Esq.*

By the Rev. J. Holme. From Denton.		By Sir H. Davy. From Eldon.		From Aycliff.	
Carbonate of Lime	63.		52.		48.9
——— of Magnesia	34.		45.2		46.6
Alumina, Red Oxide of Iron, and Bitumen	2.25	Iron	1.1		1.66
Water	.25	Residuum	1.7		2.84
	100.		100.		100.

From the hardness of our limestone beds, they furnish excellent metal for repairing the high-ways; for which purpose the stone is quarried in some places, as at Gnipe-houe, and especially at Coxwold.

In closing our account of these strata, we may observe, that as the coarse grey limestone is often schistose, so there is reason to think, that it sometimes passes into shale. It has been remarked, that in some places, as in Scugdale, there is a shale bed immediately over the limestone; and perhaps it will be found, that, in such cases, as there, little or nothing of the grey limestone exists, its place being occupied by the coarse sandy and calcareous schist into which it has apparently passed.

* Geological Transactions, IV. p. 7.

Beneath the blue limestone, we find a series of beds, corresponding with what are usually termed COAL MEASURES. These consist of

SANDSTONE, SHALE, AND COAL.

This series (marked *i*) is usually of great thickness, comprising the whole of the regular strata above the great beds of aluminous schistus, in the third range of our alum hills; and the principal part of these strata, in the first and second, viz. all those beds that intervene between the blue limestone and the schistus. It is unnecessary to point out the geographical limits of these beds more particularly, as they extend throughout the whole of this triple range of hills, from the oolite chain to the vale of the Tees.

This member of our strata consists of an alternation of *sandstone*, *shale*, and *coal;* to which also we may add *ironstone*, for this sometimes holds a conspicuous place among the other beds. It would be vain to attempt to give an exact enumeration or description of all these strata, or even to subdivide the series; for we find here a greater number of transitions and changes, and more diversity in the number, order, and character, of the beds, than in any other member of our strata. The same bed, as it respects geological position, is in one place, a solid sandstone; in another, contains nothing but shale; and in a third, presents alternate layers of both: the transitions being frequent, and often sudden. The coal is subject to the same variations. In one spot, you will find numerous thin seams running in the shale; in another, a single seam; and in others, none at all. Sometimes the shale and coal predominate in the higher part of the beds, and sometimes in the lower part; and not unfrequently the sandstone almost excludes both; beds of schistose sandstone usurping the place of the shale. Hence, when we have noticed the order of the beds in one place, we cannot calculate upon finding the same series in another

place; for on proceeding a little distance from the place examined, we may find an almost entire revolution in the number and order of the strata. In some instances, however, the series proceeds to a considerable distance, without being much disturbed.

As the alternating beds are subject to such transitions, we are not to expect any uniformity in their respective qualities. The sandstone is of all descriptions; hard, and soft; fine grained, and coarse; schistose, and massive; white, grey, yellow, mottled, blue, light brown, and dark brown. The schist is, in some instances, blue, sandy, and micaceous; in others, yellowish and ochrey; in others, black, fine grained, and highly bituminous; and not unfrequently, the same bed contains shale of various qualities blended together. A mixture of sandy and bituminous shale is very common. The coal is also of various descriptions; some of it being little superior to the bituminous shale, while other parts, particularly in the middle of the seams, are of an excellent quality, breaking like the best coal, into cubical fragments, with smooth shining surfaces. It is scarcely necessary to add, that the ironstone of this series is as variable as the strata in which it is imbedded.

Having made these general observations on the beds of this series, let us proceed to notice their order and appearance in some particular places, especially in the sea cliffs; and to mention some of the more remarkable beds, both there and in the interior.

To shew the connection of this series of beds with the strata above them, it may be proper to give the following list of the whole strata at Cloughton wyke, including those already described. We find there,

1. Thick beds of sandstone, forming the upper part of the cliff at the south-east cheek of the bay, or wyke.

2. A considerable bed of shale, which, with the sandstone, runs out towards the inner part of the wyke.

3. Rough coarse sandstone, partly calcareous.

4. Calcareous sandstone, or arenaceous limestone, hardened with iron, and containing shells.

5. Grey limestone, of a dusky colour.

6. Blue limestone, forming a bed of considerable thickness.

7. Thin seams of shale, partly bituminous, alternating with thin beds of sandstone.

8. A massive bed of sandstone, 8 or 10 feet thick.

9. A bed of shale.

10. Schistose sandstone, splitting into thick slates, or flags.

11. Bituminous shale, of a fine texture, with a mixture of coal.

12. Whitish sandstone; the lowest bed at the wyke.

This series is not seen complete in any one spot, for as the higher beds in the list are found only on the south side of the wyke, so the lower beds do not appear till we reach the north side, the rise of the strata being in that direction.

A bed corresponding with No. 7 is usually found under the blue limestone wherever it occurs. It varies greatly in its composition; sometimes, as here, presenting a mixture of shale and sandstone, in alternate seams; sometimes, as in Scugdale, consisting of sandy shale; and sometimes composed entirely of schistose sandstone, of which we have an instance in the ravines below Sneaton. Under all these variations, the bed retains more or less of its bituminous quality.

No. 10 affords very good flags, for which purpose it has been sometimes quarried. Some of the other sandstone beds at this wyke, and to the north of it, are also quarried, for architectural uses.

In No. 11 we have the first decided appearance of coal. A little to the north of the wyke, beyond the place where the higher strata are interrupted, as noticed in p. 103, a seam of coal is found, which has sometimes been wrought. Like the other coal seams along the shore, it is so thin, that, unless where it is of very easy access, it will

scarcely repay the expense of working. This bed and the strata above it, rise rather rapidly in the Cloughton cliffs; while fresh beds of sandstone and shale appear beneath.

Here, however, the lower beds are soon entirely concealed, by a remarkable slip of the upper strata, extending longitudinally along the shore, like the slip between Cayton mill and Scarborough; and producing, like that, a higher and a lower cliff, with an extensive platform between them. In the higher cliff we see the strata in their regular order, as at the wyke: but in the lower cliff, which is washed by the sea, they are, as might be expected, broken and irregular. The intermediate platform, which no doubt was once on a level with the surface at the top of the upper cliff, is of considerable extent; being in some places nearly a furlong in breadth, and reaching in length above half a mile, the slip terminating at Haiburn wyke, the next remarkable creek on this shore. The falling of this slip comes within the reach of tradition. It is said to have taken place at the distance of about four generations, or within the last 200 years.

At the back of Haiburn wyke, the strata are again interrupted, by the deep valley, or ravine, through which Haiburn beck flows into the sea. That this interruption has not been produced by the stream wearing its channel, nor by the mere washing away of the strata, may be inferred from the singular appearance of some large beds of sandstone at the mouth of the beck, on the north side. These beds are curiously bent, in the form of a segment of a circle, with the hollow part uppermost; indicating, that the interruption at this wyke has been connected with a depression, break, or curvature, of the strata. The broken appearance of the strata, for some distance to the north of this spot, serves to corroborate this idea.

Beyond this interruption, we again meet with steep and lofty cliffs, in which the strata are continued in regular order. And here we may remark, that as the strata, after their rapid rise from Cloughton

wyke, become nearly horizontal in the high cliffs to the south of Haiburn wyke, so they preserve a similar direction in the Stainton Dale cliffs, their rise being for the most part very gradual.

From what has been observed concerning the transitions and variations in this series, it will not be expected, that the beds in the Stainton cliffs, will correspond exactly with those at Cloughton wyke. The following is a summary of the strata, at some distance to the north of Haiburn wyke:

1. Thick beds of sandstone, reaching the alluvial surface.
2. A thin bed of shale.
3. The grey limestone.
4. The blue limestone.
5. Another thin bed of shale.
6. A bed of sandstone of vast thickness.
7. A very large bed of bituminous shale, containing thin seams of coal, and thin beds of schistose sandstone.
8. A thick and massive bed of sandstone.
9. A considerable bed of shale, descending to the beach.

This series does not proceed far undisturbed; for in advancing northward, we soon meet with another longitudinal slip of the strata, of far greater magnitude than any thing of the kind which we have yet noticed. It is fully two miles in length, and in some places about a quarter of a mile broad. Here we find double cliffs, as at the Cayton and Cloughton slips, and a large tract of pasture ground intervening, with some coppice wood. The lower cliff, as at the other slips, is greatly broken and dislocated; while the cliff that rises behind the platform, and which in most places is of a much greater thickness, presents the strata in their regular position. The platform is by no means a uniform level, the enormous mass of land that has sunk down, having been rent and disordered in its fall; the fore part generally swelling into an irregular ridge, while the back part, sink-

ing much lower, has become a long hollow trough behind it, affording, as at the Cayton slip, a lodgement for stagnant waters. These waters form several pools and marshes, and would accumulate into a considerable lake, were it not for the breaks and cross fissures of the ridge, through which they have outlets towards the sea. The ridge is not only divided by these cross fractures, but often exhibits in front a succession of terraces, occasioned by a like number of longitudinal rents.

It would be of little use to attempt a particular description of the broken strata in the lower cliffs, which sometimes consist of a confused mixture of the inferior beds of the series with those which the slip has brought down from above, and sometimes of the latter only, the former being sunk or thrust out.

The following is a sketch of the strata in the higher cliff, taken about a furlong from the northern extremity of the slip :

1. Sandstone at the top of the cliff; occupying about 60 feet.
2. Shale, with seams of schistose sandstone; about 80 feet.
3. Grey and blue limestone; 15 feet thick.
4. Shale; about 4 feet.
5. Hard sandstone; 25 feet.
6. Shale; 30 feet.
7. Sandstone; 25 feet.
8. Shale; 50 feet.
9. Sandstone; 16 feet.
10. Shale; 60 feet.
11. Great bed of sandstone, of a very dark brown colour, and coarse grain. This is the lowest accessible bed, and its thickness could not be ascertained, the inferior part of it being covered up.

The whole series may be nearly 400 feet in thickness, the cliffs at this place being very lofty. The dimensions of the beds, however, are not given from actual measurement. The inferior beds of sandstone

and shale, covered up by the slip, may occupy another 100 feet, or upwards; making the whole thickness of the strata, above the level of the sea, about 500 feet.

In some parts of the sandstone bed No. 5, there are quantities of calc spar in the fissures or crevices. Some of the crystals are of the long pyramidal form, called dog-tooth spar; and are highly transparent, with a yellow tinge. Aggregated masses of such crystals are sometimes found in fissures or cavities, with their bases adhering to one side of the fissure, while their diamond points, crowded together, form a curiously indented surface. Similar aggregations occur in the fissures of the oolite, and of the beds immediately beneath it. It may be questioned, whether the calc spar of this sandstone, has originated in the calcareous matter belonging to the stone itself, or in what has descended from the limestone above it. The latter is the more probable, as the same kind of spar is found in some of the fissures of the limestone itself.

The beds below No. 11 consist of an alternation of sandstone and shale, with a small portion of coal and of ironstone. This lower part of the series may be seen immediately beyond the termination of the Stainton slip, particularly at the point where the great bed of alum schistus first makes its appearance. The beds of arenaceous and bituminous shale are perhaps more numerous at this spot, than at any other which the authors examined. Between twenty and thirty beds, or seams, may be counted in the front of the cliff, alternating with sandstone of various kinds; the large beds mentioned above being here subdivided.

The transition of sandstone into shale, or of shale into sandstone, so common in this part of the strata, is sometimes sudden, and sometimes very gradual. In general, where the shale passes into sandstone, we first find seams of sandstone running into the shale, and these seams gradually thicken, till the shale is completely thrust

out. The order is of course reversed, where the sandstone passes into shale. Not unfrequently, where beds of shale and sandstone alternate, we find a bed of shale enlarging its dimensions, so as to encroach on the sandstone above or below, which is hence reduced to a thin seam, if not thrust out altogether: or *vice versa*, a seam or small stratum of sandstone may be seen swelling into a vast bed, compressing the shale above or below it into a small compass, or entirely excluding it. Instances of such transitions may be seen in abundance along the coast, as in the cliffs between Whitby and Upgang, and especially at Hawsker Bottoms, and the cliffs opposite Gnipe-houe. In the latter place, the sandstone a little above the alum rock suddenly acquires an immense thickness, forming a massive bed about 40 or 50 feet thick; but this bed continues only for a short space, being again subdivided into thinner beds, interstratified with shale. Remarkable transitions may also be observed in the beds that form the cover of some of the alum-works, particularly those of Stoupe Brow and Lofthouse.

Though the shale of this series is generally either sandy and micaceous, or bituminous, or a mixture of both, yet in several instances it contains a large proportion of clay. This is the case with a bed of shale at the upper end of Tripsdale, a branch of Bilsdale. It has a dark brown colour, and a soapy feel; and is easily divided into thin plates, which in their recent state are soft and elastic, but when prepared by being roasted in hot turf ashes, are used by the inhabitants of the neighbouring vales for baking cakes, being capable of bearing the heat of a common fire for several years. From the use to which these plates are applied, the ravine where they are obtained is called *Bakestone-gill.*

The shales of this member of the strata contain very few animal remains, but in the bituminous shale above the coal seams, we find abundance of vegetable impressions.

Many of the beds of shale contain balls or nodules of ironstone, usually arranged in layers or courses, parallel to the strata in which they are imbedded. In some instances, the nodules are so numerous as to form nearly a continuous stratum. The ironstone is usually very hard; but in many places we find it in the form of a rich yellow, or yellowish brown, ochre; which occurs in seams as well as in balls. This ochre exists in considerable quantity in the fronts of some of the Cleveland hills. In the upper end of Greenhoue Burton, there is a seam of red ochre, or ruddle, of a dark red colour. Like the yellow ochre, it is of a fine grain, and soils the fingers. The farmers, who collect it for marking their sheep, give the cliff where it is found the name of the *Rudd scar*.

Ironstone is common in the sandstone, as well as in the shale; sometimes occurring in balls or patches, sometimes in seams incrusting the sandstone, like the ironstone between Scarborough and Cloughton wyke. There is a very hard seam in the cliff at Saltwick near Whitby, remarkable for the remains of plants which abound in it. The stems of the plants appear to have been converted into calc spar, which has been decomposed into a fine white powder, resembling the finest flour. The stone is partly argillaceous, partly calcareous, with a very considerable proportion of iron.

The coal seams appearing in the sea cliffs are all too inconsiderable to be wrought with advantage. In a few instances, however, workings have been commenced, and afterwards abandoned; particularly at Cloughton wyke, as noticed above; and at Hawsker Bottoms, near Whitby. The coal at the former place is the highest seam occurring in our strata, and that at the latter place is the lowest, being only a few yards above the alum schist. The latter appears to have been the most productive, and were it more easy of access, it might yield some profit to the proprietor.

In the interior, where the hills rise to a great height, and the

strata consequently swell into a greater thickness, the coal seams are more considerable, and have been wrought for 70 or 80 years. This is particularly the case at Blakey and Rudland, in the first range of our alum hills; and at Danby or Castleton, in the second. The greatest thickness of coal is at the Danby pits, where the seam is 17 inches. The depth from the surface varies from 15 to 60 yards. The quantity of coal obtained here, may be about 200 or 300 bushels per day, on an average. The other works are less extensive. At the Blakey pits, the seam is about 12 inches; and at Rudland, it is only 9 inches: but at both places, the depth from the surface is usually less than at Danby. A new coal work has commenced at the head of Fryop, where the seam is about 16 inches, and the depth from the surface 18 yards. Another work was lately carried on at the upper part of Glazedale; and there is one also at Maybecks on the Sneaton estate, where the seam is 6 inches. Above 30 years ago, there was coal obtained at Allen Tofts in Godeland, where the seam was above two feet thick, being the greatest known in this district; but this was found to be merely an accidental swell of the coal stratum, which was soon exhausted. In almost all these spots, the seam wrought is one of the uppermost in the series, being not far below the blue limestone. The seam wrought at Maybecks, like that at Cloughton wyke, is only a few yards beneath the limestone.

As the blue limestone passes through the Hambleton hills, and appears in the valleys beyond them, so also does the coal. It has been found at Coxwold, not many yards below the blue limestone. Here a coal work commenced 16 years ago, and was continued 10 years. The seam was about 12 or 13 inches, where it was thickest; the depth from the surface varied from 7 yards to 29 yards, the seam having a rapid dip towards the north-west. The covering here, as at the pits in our alum hills, consists of sandstone and shale, the latter containing hard nodules.

In all these coal strata, the middle part of the seam usually consists of good coal, breaking into cubical fragments; while the rest is of an inferior quality, differing little from the fine bituminous shale.

As the coal seams wrought in the interior belong to the upper part of this series, it is possible, that in some places a richer seam may be discovered in a lower position, corresponding with the seam at Hawsker Bottoms, but increased in thickness, according to the greater elevation of the hills. The boring now going on at Maybecks, under the direction of the proprietor, James Wilson, Esq., will soon ascertain whether any such seam exists there or not. That gentleman having favoured the authors with the register of the borings, as far as they have proceeded, a copy of that register is here given. The spot where the experiment is making, is about 20 yards below the six inch seam of coal, already mentioned; which seam is about 15 yards below the blue limestone. The series through which the boring has been made is thus stated:

	Fathoms.	Yds.	Ft.	In.
Soil and loose stones (*i. e. alluvium*)	—	1.	1.	—
Strong brown post *(brown sandstone)*	2.	—	1.	—
Blue metal and metal stone with post girdles (*blue shale, schistose sandstone with nodules)*	9.	1.	—	—
Coal	—	—	—	4.
Grey metal stone *(grey schistose sandstone)*	4.	1.	—	—
Strong post with a mixture of whin *(sandstone with ironstone)*	—	I.	I.	6.
Grey metal *(grey shale)*	—	—	1.	6.
Dark blue metal *(blue shale)*	—	—	—	10.
Grey post *(grey sandstone)*	1.	—	—	—
Grey metal with post girdles *(grey shale with nodules)*	1.	—	—	—
Grey metal with skares of coal *(bituminous shale)*	—	1.	—	—
White post (*white sandstone*)	—	1.	—	
Grey metal	—	—	1.	2.
Coal	—	—	—	5.
Grey metal stone	—	1.	2.	—

	Fathoms.	Yds.	Ft.	In.
White post with water	—	—	1.	6.
Soft white post	—	1.	—	—
Grey metal stone	—	1.	—	3.
Black stone with a mixture of coal (*bituminous shale*)	—	—	—	6.
Blue metal and metal stone	1.	—	1.	—
Strong white post	—	—	1.	—
Blue metal with skares of coal	—	1.	1.	6.
Grey post with metal partings (*grey sandstone with seams of shale*)	2.	1.	2.	6.
Whin (*ironstone*)	—	—	—	4.
Grey post with partings	1.	—	—	—
White post with a mixture of whin	—	—	2.	—
Dark blue metal	—	—	2.	—
Whin	—	—	—	6.
Dark blue metal with skares of coal	—	—	1.	9.
Grey metal stone	—	—	2.	6.
Grey post with a mixture of whin	6.	—	—	—
Total ...	37.	—	—	1.

At the time when this list was obtained, the last mentioned bed, consisting of sandstone with a mixture of ironstone, had not been pierced through. From its great thickness, it may have some correspondence with the sandstone bed in the cliff opposite Gnipe houe; and, like that, may be very near the alum rock, which is found cropping out at Falling Foss, above half a mile further down the valley. The elevation of the surface where the experiment is making, is ascertained to be 530 feet above the level of the sea: that of the neighbouring heights near Newton House, 766 feet. There must be a bend in the strata near the place of the boring; for the limestone and other beds on the south side have a *rise* towards the south, whereas the beds at Falling Foss *dip* towards the south.

It has been already observed, that the sandstone of this series is of very different qualities, and this is obvious from the list of beds now

given. Some of the beds are very hard and highly siliceous, approaching to the character of the crow-stone. A bed of this description, which our borers would call *strong white post*, occurs in the Stainton cliffs, in a part of the series above 100 feet higher than the alum schist. It is remarkable for containing petrified reeds. The same kind of reeds are found in a bed at the top of the cliff opposite High-Whitby, probably corresponding with that of the Stainton cliffs, though inferior in hardness, and not so much elevated above the alum rock.

Many of the sandstone beds furnish excellent materials for the purposes of architecture. The freestone quarries of Sleights, Ugglebarnby, and Aislaby, are the most noted in the vicinity of Whitby. In these quarries, and many others in the strata over the alum schist, are massive beds of great thickness, from whence blocks are cut out of any size that may be wanted. The huge blocks employed in constructing the Whitby piers were brought from these quarries, particularly those of Aislaby. Great quantities of the same stone have, within these few years, been shipped at Whitby, for the piers of Margate and Ramsgate, the foundations of the Strand bridge at London, and similar purposes.

Instances of the discovery of living toads, lodged in cavities within solid blocks of sandstone, have occurred in our district, as in many other places. Some years ago, one was found in a block among the materials used at the Whitby piers. Phenomena of this description have been observed in this country at a very early period. William of Newburgh, in the same chapter in which he mentions the Gipsies, as formerly noticed, relates among the prodigies of his times, the discovery of a living toad in a block of stone; but, after the fashion of the monkish writers, he clothes his narrative with more of the marvellous than we can receive. Some men, who were quarrying stone for building, found at a considerable depth a handsome and curious block, apparently composed of two stones closely cemented

together. The block being split, in the presence of a bishop who lived at that place, there appeared in a cavity within it, to the astonishment of the beholders, a live toad, having a chain of gold round his neck! He had not also a crown on his head, but being regarded, it would seem, as the monarch of the quarry, his little dusky majesty was, by order of the bishop, again shut up in his narrow palace; and this being replaced in the centre of his territory, was deeply covered up with rubbish, that no sacrilegious hand might violate his sacred person, or despoil him of his royal ornaments.

In a marginal note on this passage of Newburgh, in the Antwerp edition of 1567, it is stated by the writer of the note, C. Lang, that in the coal pits of his country, in the vicinity of Leeds, it was very common to find large round nodules, smooth and very hard, containing live toads, in cavities in their centre, which had no visible communication with the exterior part of the stone.—About 8 or 10 years ago, a live toad was found in the grey limestone, in the quarry formerly mentioned, on the side of the York road, a little to the south of Malton. One of the most recent examples of this kind was observed about a year ago, in a coal pit in the county of Durham.

It is no easy matter to account for a phenomenon of this description; for whether we suppose that the animal is coeval with the rock which incloses it, or that the spawn which produced it has been conveyed by water through some narrow channel or pore, into the cavity where it is found in a state of maturity, we are involved in difficulties which cannot be very easily solved.

Many of our sandstone beds contain petrified wood. Fragments of charcoal, and even large branches of trees in the state of charcoal, are still more frequent. In some places we find in the sandstone, patches of real coal, but of a finer grain than the coal that occurs in seams, approaching more to jet, but not possessing its solidity, nor its conchoidal fracture. Real jet has also been discovered in the same

situations. Such coal patches have been found in the sandstone on the banks of the Esk, above the upper part of Whitby harbour.

In a great part of the sandstone strata in this series, we meet with the same appearances already described as occurring between Cayton mill and Scarborough, the beds being divided by diagonal and irregular partings, instead of presenting seams parallel to the course of the strata. Instances of this kind may be seen in the cliffs on the west side of Whitby harbour, and in numbers of other places along the coast.

Some of the sandstone of this series is a kind of conglomerate or breccia, having the appearance of sand and gravel cemented into a solid mass. A remarkable instance of this nature may be seen in the bank below the church-yard of Whitby, a few yards from the top of the long flight of steps leading up to the church. The bed alluded to bears such a striking resemblance to sand and gravel, that it almost requires the evidence of touch, to convince the spectator that it is a solid stratum.

One of the most remarkable beds in this series is the lowest member of it, viz. the bed called the *dogger*, which lies immediately over the alum schist. This is a singular species of conglomerate, assuming a variety of forms. In some places, it is a coarse dark coloured sandstone, with a mixture of light coloured grains, or minute fragments; in others, it is a coarse breccia, containing numerous small stones of various shapes, generally with rounded angles; and in others, it contains shells and petrified wood, as well as minute grains, and small stones. The base is of various colours, being brown, reddish or purplish, dark yellow or ochrey, dark grey, ash-coloured, and olive. It is no less various in its composition, being sometimes so calcareous as to effervesce with acids, sometimes an argillaceous sandstone, sometimes rather siliceous, and not unfrequently a kind of clay ironstone. Iron is a very common ingredient in this rock, and sometimes appears in considerable quantity.

The imbedded fragments are still more diversified than the base that includes them. Some are calcareous, others siliceous, others argillaceous; some are hard, others soft; some are crystalline and transparent or translucent, but the greater part are earthy and opaque; some are flat, but more are roundish; some have sharp angles, but a greater number are smooth or blunted; some have the appearance of concretions, like the ova of the oolite, but most of them seem to have once belonged to other rocks. They are of all sizes, from the most minute grain, to the size of a pigeon's egg, which they rarely exceed. They also exhibit a great variety of colour, most of them being whitish, giving the stone a speckled appearance; whilst many of them, especially the larger pebbles or fragments, are of a dusky colour, and others black, blue, green, &c. Of the crystalline fragments, some consist of siliceous crystals, others of calc spar. Many of the white specks in this stone appear to have resulted from the decomposition of such crystalline fragments.

Besides the crystalline substances derived from pre-existing rocks, there are other crystals in many specimens of the dogger that seem to belong to the stone itself, or that have been formed in it. Some of these crystals are diffused through the stone, others are collected in thin masses. The most singular mineral found in the latter state is *galena* or *lead-glance*, which exists in slender veins, or in crevices, accompanied with a sparry substance. It has its usual metallic lustre, and lamellar structure; but is found in very small quantity. The authors have observed it only between Whitby and Saltwick, and above the alum works at Sandsend.

In many places the *dogger* consists of but one bed, which is thick and hard; but very often it is divided into several beds. The stone, whether consisting of one bed or more, is very frequently split into numerous blocks, by vertical partings or cross fissures. These fissures or cracks, however, are not open, but filled with thin

ferruginous *laminæ*, or plates, that seem to have shivered off from the blocks, or with ochrey clay, apparently resulting from the decomposition of such laminæ, or of the solid stone. In such instances, and indeed throughout most of its extent, the dogger contains a considerable portion of iron; and rusty coatings often exfoliate from the stone, where it is exposed to the action of the atmosphere. Ferruginous plates, however, sometimes accompany the dogger, in situations where they can scarcely be supposed to be exfoliations, being dispersed in seams of shale, or of schistose sandstone; in which situations nodules of ironstone also occur. Thus, in a part of the cover of Sandsend alum rock, the dogger comprises the following beds:

1. Hard ferruginous sandstone; 1 foot.
2. Schistose sandstone, containing rusty plates; 6 inches.
3. Solid blocks, divided by vertical fissures, containing rusty plates and shale; 3 feet, 6 inches.
4. Shale, containing plates and nodules of ironstone; 3 feet.
5. Another bed of blocks, with cross seams, as in No. 3; 3 feet 6 inches.—This bed lies immediately over the alum schist.

As an additional illustration of the nature and connections of the dogger, we subjoin a list of the whole beds covering the alum rock, at Littlebeck:

1. Arenaceous shale, containing nodules of ironstone, immediately under the alluvium; 20 feet.
2. White sandstone, containing fragments of charcoal, with substances resembling roots of shrubs; 2 feet.
3. Another bed of sandy shale; 2 or 3 feet.
4. White sandstone, with fragments of charcoal; 1 foot.
5. Schistose sandstone, or very sandy shale; containing ironstone, partly in nodules, partly in veins or plates; 3 feet.
6. Coarse sandstone, being properly the first bed of the dogger; 1 foot.

7. Second bed of dogger, of a blueish colour, with numerous specks, some of which are white, and some black and shining; 1 foot and a half.

8. Third bed, of a brownish colour, with blue patches or seams; 2 feet.

9. Fourth and lowest bed, lying immediately over the aluminous schistus, of a brownish colour; 3 or 4 feet.—The last three beds are parted by cross fractures, in which is found, as in other parts of the dogger, ferruginous matter in plates or veins, or in a kind of powder. In these beds also, especially in No. 8, we find quantities of shells, not generally diffused through the stone, but in clusters or groups, here and there. The shells are most numerous among the ferruginous matter that fills up the cracks or cross fissures.

At Falling Foss, which is in the same valley, about a mile further up, the dogger beds are of a similar description, but inferior in thickness. They contain a number of shells, which are most abundant in the seams between the blocks. Where the shells occur, the stone not only contains much calcareous matter, but is strongly impregnated with iron, and hence many of the shells have a blueish or iron-grey coating, while others appear rusty or ochreous. It is rather singular, that the shells correspond with those which occur in the oolite, more than with those in the aluminous schistus.

In the sea cliffs at Peak, where the dogger first makes its appearance, it is composed of thick beds of coarse argillo-calcareous sandstone, of a dark grey or dusky colour, containing little iron, but abounding with specks of mica. Here also organic remains occur in considerable quantity, partly dispersed throughout the stone, but principally in calcareous patches or nuclei, imbedded here and there.

To this account of the dogger we may add, that in the hills fronting the plain of Cleveland, as at Guisborough, Ayton, Carlton, &c., there seems to be no bed corresponding with it; or perhaps it

may be more correct to say, that in these hills it loses its conglomerate character, and passes into common sandstone.

Having described the series of strata intervening between the blue limestone and the aluminous schistus, we might notice the remarkable undulations and breaks in these strata; but it will be most proper to defer our account of these phenomena, till we have taken a view of the next member of our strata, viz.

THE GREAT BEDS OF ALUM SHALE.

The aluminous schistus, as has already been intimated, forms a most important feature in the three ranges of hills in the northern part of our district, which we have therefore denominated the *alum hills.* This schistus forms beds of immense thickness, interstratified with seams, or thinner beds, of various descriptions. It begins to rise above the level of the sea towards the northern extremity of the Stainton Dale cliffs, nearly a mile to the south of the Peak; and is continued along the coast, with a few interruptions which will be noticed, to Saltburn and Redcar, at the mouth of the Tees. On the western side of the hills, it first makes its appearance at Thimbleby, near Osmotherley, where it rises from under the north-west skirts of the Hambleton hills; and from thence it proceeds along the western and northern fronts of the Cleveland hills to the mouth of the Tees; leaving, however, a considerable plain, between the fronts of the hills and the river Tees, where no alum rock is found.

To give a more distinct view of the aluminous strata, and the beds subordinate to them, it will be best to describe them as they appear in the lofty cliffs at Boulby; where these strata are more entire than in almost any other spot, and at the same time are of easy access. The whole series of beds, from the summit of the cliffs down to the beach, may be thus enumerated:

1. The alluvial covering; 5 feet.

2. Beds of sandstone; 50 feet.

3. Shale, sandy and bituminous, with a few seams of sandstone: 30 feet.

4. Sandstone, with a few seams of shale; 25 feet.

5. Dogger; 5 or 6 feet.

These beds bring us down to the alum works, which are carried on in the next member of the series.

6. Main bed of aluminous schistus, or alum rock; 200 feet.

7. Imperfect seams, or flat nodules, of hard blue limestone, mixed with alum shale; 10 feet.

8. Hard and compact alum shale; 30 feet.

9. Ironstone, in beds, or rows of nodules, interstratified with the shale; 15 feet.

10. Shale, with a few ironstone nodules; 40 feet.

11. Beds of argillo-calcareous sandstone, with some shell limestone, interstratified with seams of shale; 60 feet.

12. Alum shale; 100 feet. This bed comes down to the beach, where a hard blue shale, on which it rests, is washed by every returning tide.—The shale that occurs below No. 8 is generally somewhat sandy and micaceous, and of a coarser texture than the higher beds.

By adding the numbers in the foregoing list of beds, it will be found, that the height of the whole series has been estimated at about 570 feet, exclusive of the sloping bed on the beach. This estimation falls a little short of the truth; for the beacon on the heights near Boulby (which Colonel Mudge calls *Easington Heights)* is 681 feet above the level of the sea; and the difference of altitude, between that beacon and the verge of the cliff in front of it, is much less than 100 feet. The beds, however, vary in thickness, in different places; though they are much more uniform in their nature and order than those of the series last described.

Having taken this general view of the alum shale, and the beds subordinate to it, as they appear at Boulby, let us notice more particularly the nature of the different beds, in their order.

The first and principal member of this series is the MAIN BED OF ALUM SHALE, marked *(k)* in the Section. This bed varies from about 180 to 200 feet in thickness. It has the laminated or slaty structure, parting horizontally into plates, which are more or less thin, according as they are higher or lower in the bed, the lowest parts of it being the least fissile. This difference, however, may result from a difference of exposure and of pressure, more than a real diversity of structure; for the most compact blocks, taken from the lower part of the bed, soon split into thin laminæ, when exposed to the atmosphere, and released from the pressure of the superincumbent mass. The slaty fragments, under the continued action of the atmosphere, will split again into very thin *lamellæ*, which are blown about with the winds.—Besides these horizontal partings, this rock is divided by vertical seams. These are disposed in two sets, the seams of each set being parallel to one another, but crossing those of the other set obliquely; and hence, by the intersections of these two sets of seams, the rock is split into rhomboidal blocks. The seams, however, are not placed at regular distances, so that the solid rhomboids are more or less oblong; and since these vertical fissures, like the horizontal partings, diminish in number as we descend, the rhomboidal sections grow larger and more compact, according to their depth. Sometimes the two sets of vertical seams cross each other nearly at right angles, dividing the rock into parallelopipeds, rather than solid rhomboids. We may add, that, of the intersecting veins or seams, some are principal veins which may be traced to a great distance; others are subordinate, running only a short way in the rock.

When broken in the direction of the laminæ, the alum schist presents a smooth fracture, and very fine grain, and feels rather soft and

unctuous, especially in the upper part of the beds. The cross fracture is dull, and somewhat rough and hackly. The rock is of a dark slate colour; but when pounded has a lighter hue, resembling grey clay. The cross seams, as in some varieties of coal, are often filled with a kind of coating, and occasionally with calc spar. The coating is generally an efflorescence of sulphate of alumine, mixed with oxide of iron, which last gives it a rusty colour. The efflorescence sometimes increases by exposure to the air, and the rusty coating tends, under favourable circumstances, to preserve the rock from further decomposition.

The schistus of this bed is found to contain alumine, silex, magnesia, lime, oxide of iron, bitumen, sulphur, and water: the proportions of which vary considerably in different parts of the bed. Alumine, or pure clay, is of course a principal ingredient in every part of it; the proportion being often 30 per cent, or upwards. It also contains a large proportion of silex. The sulphur is most copious in the upper part of the bed, and the bitumen in the lower part. A considerable portion of lime is also contained in the schist, being not only found in seams or veins in the state of calc spar, but diffused in some degree through the mass of the rock. The minute shining specks generally discernible in the surface of the laminæ, are probably crystals of selenite rather than mica. Selenite is often found in the seams, in fine diverging crystals, crossing one another. The same mineral also occurs in considerable quantity among decomposed shale, particularly in the old alum works. The formation of crystals of this kind is a process still going forward; for we often find them among rubbish at the alum works, in circumstances which clearly prove, that they must have been formed since the rubbish was deposited.—The specific gravity of the schist is, on an average, about 2.48.

It is from the upper half of this bed that alum is extracted. The dogger and other covering strata being removed, the rock is hewed with picks, &c., and the broken fragments are laid in a heap, and

calcined ; a process which is much facilitated by the quantity of sulphur and bitumen in the schist. The rock, indeed, under certain circumstances, is subject to spontaneous combustion, when suddenly exposed to moisture and the effects of the atmosphere. Some years ago, a considerable part of the cliff, in a small wyke or bay between Runswick and Staiths, fell down and took fire, and continued to burn for two or three years. The upper part of the rock, containing most sulphur, is the most valuable for producing alum, a cubic yard at the top producing as much as five cubic yards at the depth of 100 feet. The quarrying of the rock is not carried on to a greater depth than about 90 or 100 feet, as below that depth it is too unproductive to remunerate the proprietor. The calcined shale is steeped in pits, and the lixivium being drained off, is boiled in pans, with a certain proportion of muriate of potash ; and the liquor being conveyed into coolers, deposits the crystals of alum ; which are afterwards washed, and dissolved by boiling, to be re-crystallized in a purer state.*

The main bed of alum shale abounds with petrifactions, consisting of wood, bones, but especially shells, among which the ammonites (the well known Whitby *snake-stones*) hold a conspicuous place. The petrified substances often occur in a detached form among the schistus, but they are more frequently enveloped with a crust, or included in hard nodules. These nodules, which occur in almost all parts of the aluminous strata, are generally of a kind of blue limestone, combined with pyrites ; which last often forms the outer crust of the nodules, and also penetrates them in the form of veins. Sometimes

* For a more full account of the process of making alum, the history of the alum works, &c., see History of Whitby and the Vicinity, Vol. II. p. 806—817. See also Mr. Winter's Essay in Nicholson's Philosophical Journal for April, 1810. In that Essay, however, there are a few mistakes. For instance, it is asserted, that both the sandstone and schistus, in the alum district, are traversed by veins intersecting each other at right angles, so that "their masses *always* appear in the form of solid parallelograms"; when the truth is, that the sandstone is extremely irregular as to its partings, and the seams of the schistus for the most part cross each other obliquely, dividing the rock into rhomboidal masses.

the nodules consist of solid masses of pyrites, with little or no limestone. They do not always contain organic remains. It is scarcely necessary to add, that alumine and silex enter into the composition of these stones, as well as lime and pyrites, though the two last are the principal ingredients.

These nodules are commonly of a lenticular or discoidal shape, like flattened globes. Some of them are nearly or entirely globular, which is particularly the case with several of the smaller nodules, from 4 or 5 inches to 8 or 10 inches in diameter; the larger masses being always flattened, many of them resembling millstones with thin edges. Several of the flat nodules are oval, and others are of an irregular shape; but the circular form is by far the most predominant. It is of more importance to observe, that whatever form the masses may assume, their flat surfaces or planes are always parallel to the surface of the general bed; and where they run in rows or courses, as is often the case, such courses preserve the same parallelism, being horizontal where the strata are horizontal, and dipping where they dip. This remark, which we formerly made concerning the nodules of flint in the chalk, and nodules of limestone in the argillo-calcareous sandstone below the oolite, is equally applicable to the ironstone nodules occurring in the shale, both in the alum hills and in the oolite district. Even the globular masses in the alum shale are surrounded or marked with circular zones, the planes of which are parallel to the plane of the strata in which they are imbedded.

In the quarrying of the schistus for the purpose of making alum, the nodules are all thrown aside. When long exposed to the air and the rains, they are partially decomposed, the sulphur of the pyrites evaporating, and the iron undergoing oxidation; and hence they exchange their blue or brassy aspect for a red or ferruginous hue, and losing their extreme hardness, are split into shivery fragments. It is observable, however, that the nodules which roll about in great

numbers on the beach usually preserve their colour and their solidity, the sea water preventing their decomposition. Within the last ten years, the nodules have been collected, at some of the alum works, to be employed in the manufacture of *terras*, or *Roman cement*. For this purpose, they are burnt in a kiln; then broken, and pounded with stampers, and lastly ground to powder in a mill. This powder, when mixed up properly with water, forms a durable cement. The nodules that contain much pyrites are rejected as unfit for this use, the more calcareous nodules being the best.

Many of the nodules contain calc spar, which often occurs among the petrifactions; the chambers of the ammonites and nautilites being usually filled with it. Siliceous crystals are not uncommon in similar situations, the cavities in the nodules being sometimes lined with them. Several of the nodules are of the kind called *septaria*, being traversed by *septa*, or cross veins, dividing them into compartments. These for the most part abound with calc spar.

In the cavities of the septaria, and other nodules, we sometimes meet with *petroleum*, or mineral oil. When first exposed, it is generally quite fluid, and of the colour of oil; but it soon becomes viscid and black, and at last hardens into a kind of pitch, which readily melts with heat, and when ignited burns with a crackling noise, and emits a strong bituminous smell. It is occasionally found in the viscid, or in the hardened state, at its first exposure. As this substance is usually, if not always, accompanied with animal remains, being most commonly found in the chambers of nautilites and ammonites, it may be questioned, whether the animal oil, belonging to the shellfish, may not have contributed to its formation.

Some of the larger nodules or blocks, of a rounded or oval shape, are incrusted with a calcareous substance, which has been termed *cone-in-cone coralloid*. It is composed of an immense number of cones, from an inch to six inches in height, all pointing towards the central block, having the interstices between them filled with

calcareous matter. The cones are variously aggregated; the larger containing several concentric cones within them, and one cluster often encroaching on another, or reclining on the side of another, so as almost to make their *apices* meet. When the stone is broken, the cones are very discernible in the fracture, and may often be taken out singly, or in clusters. They are transversely marked with undulating wrinkled lines, which perhaps point out the margins of the successive *lamellæ*, or coatings, of which the cones are composed. This stone has the blueish colour and soft feel of the alum schist. It is occasionally found in patches, not attached to any central block.

The *jet* that occurs in this bed, of the finest quality, and often in considerable quantity, will fall to be described in the Second Part of this Work; for it belongs to the list of organic remains, being obviously a particular modification of petrified wood.

Having given a description of the main bed of the alum rock (No. 6 of the series at Boulby), let us proceed to a lower part of the rock (No. 7), which we have stated to consist of IMPERFECT SEAMS, OR FLAT NODULES, OF HARD BLUE LIMESTONE, MIXED WITH, OR IMBEDDED IN, ALUM SHALE.

This part of the strata (marked *l*) is not, strictly speaking, a new bed, but a continuation of the same bed somewhat modified; for there is no precise line of demarkation between this part of the strata and the main bed of schistus. When the shale has descended about 180 or 200 feet, the imbedded nodules or blocks become larger and more abundant, sometimes running in the shale in lengthened rows, approaching to seams. Like the courses of flint in the chalk, they do not form any continued stratum, but the flat masses are so numerous and broad, that they may be traced in a kind of imperfect seams through a considerable space. The shale in which these courses of flat masses are imbedded, is similar to that of the main bed, but of a harder quality.

Among the imbedded masses of this part of the rock, we find the same variety as in the upper part of the schist. Some of them

are highly pyritous, others strongly bituminous; some of them abound with organic remains, others contain few or none; some are incrusted with the cone-in-cone coralloid, others are septaria.

The greater part of these flat masses are composed of a hard blue limestone, similar to what is called the *lias limestone.* Some have even designated our aluminous strata the *lias formation;* and the lias is known to be interstratified with blue shale abounding with petrifactions; but though there is some analogy between our aluminous beds and the shale of the lias strata, and both occupy a similar position among the secondary strata, it would surely be improper to give the name *lias* to the whole series, when we find here only a few courses of imbedded nodules to which that designation can be strictly applied.

Where these masses of blue limestone are overflowed by the sea, near low water, they are often perforated by shellfish of the *pholas* family, who hollow out their little cells in this smooth fine grained stone, as they also do in some of the harder beds of alum shale.

In the rocky pavement of our shores, the limestone masses are often seen elevated above the surface; the shale, which is softer, being worn or washed away all around them. Where a regular course of flat masses, like thin edged millstones, is thus exposed, it presents the singular appearance of a collection of little round eminences, each of which resembles the base of a cone. A fine collection of these protuberances, each having its millstone covering, may be seen on the shore a little to the south of Peak; and something of the same kind occurs between Sandsend and Kettleness.

Though most of the flat masses consist of a blue limestone, that has a fine grain, and a smooth and somewhat conchoidal fracture, there are others of a smoke grey colour, having a coarser texture, and a more dull and earthy aspect. The latter are remarkable for the unpleasant, and strongly bituminous smell, which they emit when struck with the hammer. In the recent fracture, there are a number of

extremely minute shining crystals, which however are scarcely discernible with the naked eye. This kind of limestone is found in other parts of Britain along with the blue lias, and is called the *black or fetid lias.**

That part of the alum rock which abounds with these large masses, or imperfect seams, of limestone, may be estimated at ten feet; though it is sometimes less, and sometimes considerably more. This part of the rock we may distinguish by the name of the *Sandsend beds*, as in tracing the series from Whitby to the heights at Boulby, we find these seams of lias first making their appearance on the shore below the Sandsend alum works.

We now descend to the next member of the aluminous strata, which consists of HARD AND COMPACT ALUM SHALE, No. 8 in the Boulby series. This also is not a new bed, but a continuation of the great bed of schistus. It differs from the upper part of the bed, chiefly in being much more solid and compact, and in containing less sulphur: and it differs from that part of the rock last described, in containing fewer imbedded nodules or masses, and those generally smaller. In other respects, its nodules are similar to those in the schistus above it. They consist of limestone and pyrites, and are extremely hard; and owing to the hardness of the rock itself, they are not very easily detached from their beds, so that they often stand out from the face of the rock as protuberances. This part of the rock often appears as a firm perpendicular wall, more or less incrusted with the rusty coating formerly mentioned. Sometimes it is also stained with a white substance, washed down by the rains, or oozing through the cross seams of the higher parts of the strata. This white

* See Mr. Horner's Essay on the Geology of Somersetshire, Geological Trans. III. p. 368. There are several varieties of fetid limestone. A fibrous and radiated kind, of a brown colour, occurs in the Sunderland rocks. A fetid limestone, of a greyish white colour, is found at the Dead Sea, and at some of the Egyptian pyramids. See Clark's Travels, II. p. 538. III. p. 130. Some of these varieties are called *stink-stone*. The emission of a gaseous sulphuretted hydrogen is considered as the cause of the strong odour.

matter, which occurs in various parts of the alum rock, seems to be akin to *rock-milk*. It contains, however, a mixture of alumine, or pure clay, along with calcareous matter.

Notwithstanding the compactness of this part of the rock, it has its vertical seams, or cross veins, intersecting one another obliquely, and dividing it into rhomboidal blocks; though its veins are fewer, and its sections are consequently larger, than what we see in the higher parts of the rock. As this schistus, like the chalk of Flamborough, has a tendency to split vertically; so, like that, it is liable to be penetrated by the sea, which forms in it curious recesses and grottos. This remark applies not only to this part of the beds, but to the alum rock in general. One of the most noted caves in the schistus is *Hob-hole* in Runswick bay, which some years ago had a most romantic appearance, having a double pillar in the middle of the entrance, as represented below.

The pillar has been demolished by the waves; but the cavern is still 70 feet long, and 20 feet wide at the mouth.*

* For an account of the superstitions connected with Hob-hole, presumed to have been the residence of a *hob*goblin, see Hist. of Whitby and the Vicinity, II. p. 883.

While the compact schistus generally presents a perpendicular face, like a vast wall, very frequently smooth and even, the whole of the aluminous beds, where they front the sea, form steep cliffs, sometimes perpendicular, and sometimes overhanging. Hence, as the higher parts of the rock have such a tendency to split, the examination of the beds beneath is attended with danger, especially after frosts, or heavy rains. Fatal accidents have in many instances occurred, by the falling of portions of the rock on persons below. The most singular accident of this kind ever known, happened about 13 years ago, on the shore between Staiths and Boulby. While two young girls, sisters, of the name Grundy, belonging to Staiths, were sitting together on the *scar*, or rocky pavement of the shore, a splinter which fell from the higher part of the cliff, and by hitting some projecting ledge of the rock acquired a rotatory motion, struck one of the girls on the hinder part of the neck, and in a moment severed her head from her body. The head was thrown forward, and rolled along the scar to the distance of several yards.

The thickness of the hard and compact schistus may be stated at 30 feet. This statement, however, is simply intended to give a general notion of its relative magnitude. Its actual dimensions cannot be given with much precision; there being no distinct line of separation, between this part of the rock and that which precedes it.

There is, however, a well defined parting, between the compact shale and the next member of the aluminous strata (marked *m*), which consists of IRONSTONE, IN BEDS, OR ROWS OF NODULES, INTERSTRATIFIED WITH SHALE.

The ironstone beds or seams of this portion of the strata bear a strong resemblance to those of Gristhorpe, Cayton, and Burniston; consisting, partly of solid seams, most of which are from 5 or 6 inches to 8 or 9 in thickness; partly of rows of nodules, having their interstices filled up with coarse shale. These seams abound with

shells, and in some instances are so highly calcareous as to form a kind of ferruginous limestone. In most places, however, they contain a large proportion of iron, which some have estimated at from 30 to 60 per cent; an estimation perhaps beyond the truth. Silex and alumine also enter into the composition of the stone. Quantities of the ore have been collected, and conveyed to Newcastle to be smelted at the founderies.

The number of the ironstone beds and the intervals between them are greatly diversified. In some places, we find only 3 or 4 seams; in others, 12 or 13, if not more. Some of the intervening beds of shale are only a foot or two in thickness, while others are three or four feet. Here the shale begins to lose its fine grain and smooth surface; becoming rather rough and sandy, with some specks of mica. Where the shale comes in contact with the ironstone, it is often partially indurated, through the effect of the iron.

In giving the series of beds at Boulby, we have estimated these ironstone seams (No. 9) at 15 feet in thickness; but they often occupy more than double that space, particularly where the seams are very numerous. As these beds rise up at Kettleness, we may denominate them, by way of distinction, the *Kettleness beds.*

The next part of the strata (No. 10), consisting of SHALE, WITH SOME IRONSTONE NODULES, may be described in a few words. It is a continuation of No. 9, but with a smaller proportion of ironstone; the latter usually presenting only a few scattered nodules, or straggling rows of nodules. We have stated this member of the Boulby series at 40 feet; but where the ironstone seams are very numerous, so as to occupy a large space, its dimensions are proportionally reduced. This part of the series and the former are so connected, that where the shale predominates, the ironstone is scanty; and where the ironstone abounds, the limits of the shale are contracted. We might therefore have considered both as forming one bed, consisting

of shale, somewhat sandy and micaceous, with ironstone seams and nodules imbedded in it, principally occupying the higher part of the bed, but often descending more or less towards the lower part.

Below this portion of the aluminous strata, we find interstratified with the shale, some beds of ARGILLO-CALCAREOUS SANDSTONE, WITH SHELL LIMESTONE. This member of the series (No. 11) forms a very conspicuous band in the aluminous cliffs, wherever it rises above the sea. It consists chiefly of sandstone, arranged in various beds; two or three of which are generally thick and massive, while the rest are more thin and schistose. The sandstone is of various colours; such as, ash grey, blueish grey, pale brown, and yellowish grey. It abounds with specks of mica, particularly in the schistose beds or seams; which also contain the greatest number of shells.

In the upper part of these beds there are two or three seams of shell limestone, consisting almost entirely of shells, with very little cement. These seams are seldom more than a few inches in thickness. Sometimes a seam of this kind may be found adhering, like a crust, to a bed of sandstone. It is also not uncommon, in this member of the strata, especially in the upper part of it, to find sandstone beds or seams covered with a crust of ironstone.

All these rocks, of whatever kind, are interstratified with seams or thin beds of shale; which, however, is often so sandy and micaceous, as to differ very little from the schistose sandstone. The whole together occupy a space of about 60 feet, at Boulby; but in several places they are not so thick, while in other places, particularly at Huntcliff, and between Skinningrave and Lofthouse alum-house, they swell to the thickness of 80 or 100 feet, a large portion of the cliff consisting of sandstone beds, parted by thin seams of shale.

As the strata now described (marked *n* in the Section) rise up at Staiths, we may name them the *Staiths beds.*

We are now arrived at the LOWEST ALUM SHALE (marked *o*),

No. 12 of the Boulby series. This is the lowest part of our strata, appearing in the sea cliffs; for the hard blue shale, forming the *scar* at Boulby, is not a new member of the series, but the inferior part of this; the shale being hardest in the lowest portions of the bed, especially where the sea water prevents or retards its decomposition. Like the main bed of aluminous schistus, this lowest shale is of great thickness. At Boulby it rises more than 100 feet above the level of the sea, and in some parts of Huntcliff, about 130 feet. Its depth below the sea is yet unexplored; for though borings for coal have been tried along our northern shores, in various spots, near Skinningrave, Saltburn, and Coatham, they have never been carried to such a depth as to penetrate beyond the blue shale. The boring at Coatham, conducted under the direction of Sir Charles Turner in 1788, reached the depth of between 40 and 50 fathoms. This may be considered as the lowest point in the aluminous strata hitherto attained; for the rocks opposite Redcar and Coatham belong to a lower portion of these strata than the foot of Huntcliff.

The lowest shale is of various qualities; but in general it is more or less sandy and micaceous. It is only imperfectly schistose; for it does not, like the principal bed, split into thin laminæ, smooth and fine grained; but has a coarse, earthy, dull aspect, and splits, or rather breaks, into rough irregular pieces. Though we speak of this shale as one bed, it is subdivided, especially towards the lower part of it, into a number of successive beds, or courses; each of which has usually a kind of hardened crust on its surface, while the rest of the bed is more soft and friable. These crusts, generally speaking, may be considered as various modifications of the shale itself, rather than bands of other kinds of rock. In some of them, the shale is indurated by a copious mixture of sand, so as to approach to sandstone; in some, it is hardened by oxide of iron; and in not a few, it derives its hardness from an increase of calcareous matter, which

the shells imbedded in it have served to augment. Sometimes there is so much lime in the shale, that it readily effervesces with acids. There are some instances, however, in which these crusts, or partings, may be said to consist of sandstone, ironstone, or limestone, rather than of indurated shale; as we may see in some of the Redcar rocks, where we find an immense number of shelving beds succeeding one another, each having its indurated surface or covering. In the beds forming the scar, opposite the alum works of Stoupe Brow and Peak, belonging also to the lowest part of the aluminous strata, we find a number of successive courses of shale, some of which are covered with considerable crusts of limestone, ironstone, or sandstone.

Nodules of pyritous limestone are as common in the lowest shale, as in the main bed of alum rock. They are generally small and often nearly globular, resembling cannon balls. Sometimes we meet with two connected together by a slender bar, like a double shot. The pyritous balls of Huntcliff have been celebrated since the days of Drayton.* Most of them contain organic remains, which are also plentifully distributed throughout the shale. The nodules are sometimes arranged in partial rows; but more frequently occur in a detached form.

Such are the different beds belonging to the aluminous series. In closing our description of them, it may be proper to remark, that while they preserve nearly the same order throughout the alum hills,

* The Rocks by Moultgrave too, my glories forth to set,
Out of their cranied Cleeves, can give you perfect Jet,
And upon Huntclip nab, you every where may find,
(As though nice Nature lov'd to vary in this kind)
Stones of a Spherick forme of sundry Mickles fram'd,
That well they Globes of stone, or bullets might be nam'd,
For any ordnance fit: which broke with Hammers blowes,
Doe headlesse Snakes of stone, within their Rounds enclose.
Drayton's Poly-olbion.

they are subject to considerable variations, in regard to their qualities, and the spaces which they severally occupy. Sometimes the upper part of the main bed of shale is sandy and micaceous, like the lowest shale. This is especially the case, where the dogger is either wanting, or materially changed; as in the top of Kirkby alum works, where the shale acquires a greenish hue to the depth of about 10 feet; and still more, at the spot where the alum shale first rises above the sea, a little to the south of Peak. There the dogger and the shale, where they come in contact, seem to have mutually exchanged some of their respective qualities; the dogger acquiring something of the softness and colour of the shale; while the shale, to a considerable depth, is sandy and micaceous like the dogger, and of a lighter grey than is usual in this bed. The shale partakes also with the dogger, in its ferruginous and calcareous matter; the latter being in some places so copious that the shale effervesces strongly with acids.

But the variations in this series are most observable, in the hard bands of limestone, ironstone, and sandstone, that run in the shale. In some places, as has been intimated, the Sandsend or lias band is contracted; in others, it is dilated: and the same remark applies still more to the Kettleness or ironstone band. The latter sometimes descends towards the Staiths or sandstone band; which is equally subject to variations, the two or three thick beds, of which it is principally composed, being in some places almost in contact with each other, while in other places they widely diverge, considerable beds of shale intervening between them. Illustrations of these remarks may be seen between Hawsker Bottoms and Robin Hood's Bay; and in the lower part of the hill at Kirkby alum works, as also in some others of the Cleveland hills.

Having taken a view of the beds composing this series, let us now attend to the most remarkable breaks or dislocations in the alum hills, and the principal undulations in their strata.

In a few instances, we meet here with longitudinal slips of the strata on the coast, similar to those of Cayton, Cloughton, and Stainton; forming a higher and a lower cliff, with a long terrace between. One example of this kind occurs at Holmsgriff, between Sandsend and Kettleness; another on the north side of the village of Runswick. The village itself stands on a kind of terrace, or rather on a series of terraces, on the side of the cliff; and it is not uncommon to find in this romantic place, houses that have shrunk down with the ground on which they stand. About 150 years ago, the whole village then existing, with the exception of a single house, sunk down in one night, the cliff giving way beneath it. The ground that sunk, which probably consisted chiefly of alluvium, was to the south of the present village.*

Dislocations of another kind, which must be nearly as ancient as the rocks themselves, are frequently observed in the aluminous strata, and the beds above them. Some of these breaks are very trivial, consisting merely in the subsidence of one part of the strata, at a vertical fissure, a foot or two below the corresponding strata on the opposite side of the fissure. Thus at a place below Sandsend alum works, near Holmsgriff, we find on the scar a fracture of the schistose beds, running out obliquely from the cliff, in the direction of one set of the cross veins. It runs in two parallel lines, two or three feet asunder; and the surface of the bed on one side is a foot or more below the surface on the other side; while the intermediate space, between the two parallel lines, forms a sort of inclined plane connecting the higher surface with the lower. This intermediate part is much disordered and shattered, the broken edges of the laminæ of the schist standing up on the higher side, giving evidence of the violent manner in which the dislocation has been effected. A little

* For a more full account of this catastrophe, see Hist. of Whitby &c. II. p. 649.

further on, at Kettleness point, a similar break is perceived. It has only affected one of the cross veins, but the subsidence has been greater than at the former slip, the difference of level between the corresponding beds on the opposite sides of the fracture being nearly six feet. The redness of the ironstone bands makes this break very conspicuous.

Such breaks, however, are scarcely worthy of notice, when compared with the enormous dislocations of the strata observed in other parts of the alum hills. Of these the largest is that of Peak, a view of which is given in the Frontispiece to this Work. The view is taken from one of the outermost ledges of the broken rocks, lying off the north-east point of the promontory. To the left, that is, to the south, is seen, at the distance of about a mile, the point where the alum schist, covered with the dogger, first rises from the sea. The gradual ascent of the schist and its covering is partly concealed in a recess on the shore, so that their progress is not observed from that point of view, till they have acquired a considerable elevation. They are seen forming a prominent feature in the cliff on the left hand, with sloping banks of rubbish at their base, and above them an extensive slope of sandy and coaly schistus, rising to a great height, and surmounted by massive beds of sandstone, which are the highest rocks at the Peak. The whole of these strata advance northward without interruption, till they pass the summit of the Peak, immediately beyond which, we find the upper strata discontinued, and a huge mass of sandstone strata, apparently brought down from the strata at the top, may be seen near the middle of the cliff, on a level with the dogger beds and the lower part of the sandy shale. Adjoining to this sandstone mass on the north, and directly over the three female figures, we come to strata of a very different description, forming a steep cliff, descending suddenly to the sea. At the top of this cliff, which has a triangular summit when viewed from the sea, there is a

portion of the lowest part of the *Staiths beds*, beneath which is the *lowest shale*, occupying, as at Boulby and Huntcliff, more than 100 feet, and stretching along the shore towards the right, that is, towards the north-west. Here, therefore, a dreadful convulsion must have occurred, either by the elevation of the strata on the north, or the subsidence of those on the south; and as the dogger, on the left hand side of the slip, is nearly on a level with the inferior part of the Staiths beds, on the right; and the beds here seem to be of the same general thickness as at Boulby, we cannot estimate the quantity of subsidence at less than THREE HUNDRED FEET!

The place of the fissure in the cliff is concealed by alluvium, broken shale, and rubbish, heaped together in wild confusion; and the whole shore bears marks of violent disruption. The rocks in the foreground, where the females are collecting limpets, consist chiefly of the upper part of the Staiths beds, which are stretched out to a considerable distance from the point. On the west and north-west, these rocks abut against the ends of the very lowest visible beds of the alum shale, with their indurated coverings, corresponding with the beds at Huntcliff foot, or with the Redcar rocks. As these beds and the Staiths beds meet at right angles, and dip in different directions, the line of junction on the scar is remarkably distinct; and it presents very strong indications, that the break has been occasioned, not by the elevation of the beds on the north, or north-west, but by the subsidence of those on the south or south-east: for while the beds of the lowest shale are comparatively little disturbed, the Staiths beds that meet them, and are a little above their level, are terribly broken and shattered; and portions of them stand up with sharp edges at the line of junction, as if thrust into that position by the violent crash of their subsidence. To the south of this first and principal fracture, we meet with a succession of fractures, in the strata along the shore; so that portions of the Kettleness beds, and presently after the Sands-

end beds, make their appearance; bringing us to the main bed of alum shale: but the rocks have been thrown into the greatest disorder, dipping in all directions, and presenting numerous bends and dislocations. Thus it appears, that the subsidence has not taken place all at once, in a single fracture, but in successive breaks.

As the main bed of the aluminous schistus exists, to a certain extent, at this point, an alum work was formerly carried on at the shore, immediately to the south of the great slip; but the present Peak alum works are on the north side of the slip, and consequently are at a great height above the shore. Their position is faintly seen in the View, near the highest part of the back ground on the right. It may be proper to add, that the sketch was taken when the tide had begun to cover some of the lowest parts of the scar.

That this great slip has been nearly coeval with the strata themselves, is obvious, not only from the bends or contortions in some of the beds, which must have taken place when they were in a semi-indurated state; but also from there being no vestige of it on the surface, the alluvial covering filling up the chasms and inequalities above, and thus affording proof of its having been deposited after this catastrophe. There is nothing in the shape of the hill above, that gives any indication of such a break; for, though the strata on the south have subsided 300 feet, the upper part of those on the north of the slip have been so washed away, previous to the deposition of the alluvium, that the hill, instead of falling to the south and rising to the north of the great fracture, presents an appearance just the reverse. This precludes the possibility of tracing the slip to the westward, or ascertaining the extent of its course into the interior.

From the promontory of Peak to the north side of Robin Hood's Bay, the upper strata are not found along the shore; having been washed away or removed, probably at the time of the great subsidence. We find the main bed of alum rock, with its covering, at the alum

works of Peak and Stoupe Brow, not only at a great elevation above the shore, but at the distance of about half a mile from it. In the interior of the bay, which appears as a fine sloping crescent, forming the district called Fylingdales, the upper aluminous strata are entirely wanting, and the lower are covered with a deep alluvium. In a few places, the alluvium comes down to the beach, the rocky cliff disappearing; but most of the bay is encircled with a steep cliff, composed of the lowest shale, with hard bands running in it. The scar, or rocky pavement, washed by the tide, consists of the lower part of the same beds. Here also we perceive, in several places, marks of subsidence and disruption. On the north side of Peak, near the great slip, the strata dip toward the south. In following the curvature of the bay, below the alum houses of Peak and Stoupe Brow, we soon find them dipping to the west, which they continue to do in the interior of the bay. At the stream which descends from Fyling mill, we find a small break, the strata on the south being lower than those on the north. At some distance to the north of the stream, and a little to the south of the village of Robin Hood's Bay, we meet with a succession of small breaks, not parallel to each other, but at various angles. These breaks are rendered conspicuous by the change in the dip of the strata, attending most of them. At the commencement of the breaks, the strata dip westward; beyond the first or second, the dip is towards the north-west; and at last, opposite the village, the strata dip northward. Thus in the whole of the semicircular margin of the bay, the strata dip towards the land, and raise their broken edges towards the sea; having a south dip on the south side, a west dip in the bottom or west side, and a north dip on the north side.

Some interesting appearances are presented at the breaks near the village; the positions of the strata being very distinctly observed, owing to the hard crusts or bands covering the successive beds of shale. At some of the fissures, the strata alternately rise and fall;

being in some spots higher on the one side of the break, and in others on the opposite side. In one or two instances, we find two breaks meeting in a point, near low water; and instead of crossing each other, the one is arrested in its progress on meeting the other, an angular portion of the strata being inclosed between them. Where the dip of the strata is altered by the breaks, it is curious to observe the disrupted beds meeting each other from different directions, and at various angles. But the most singular phenomenon exhibited here, is a break where the strata on the opposite sides do not correspond, the one having, at the time of the dislocation, moved several feet before the other. Such horizontal movements may have taken place at several other slips without being perceived; but here the fact is strikingly obvious, from the arrangement of the strata into hard beds or crusts, rising in ridges, with soft shale between them, hollowed into long furrows: for at this slip, the broken edges of the hard shelving strata, instead of lying opposite those from which they have been torn, are opposite the hollow furrows on the other side. As the ridges are nearly at an equal distance from each other, and the horizontal movement of the beds on one side is about half that distance, this curious alternation goes on as far as the break can be traced, the end of each hard bed on the one side being opposite to the soft shale on the other.

On the north side of Robin Hood's Bay, the strata having acquired a northerly dip, continue to sink in that direction, as far as the northern part of Hawsker Bottoms, opposite Gnipe-houe. In the lofty cliffs occupying this space, the upper beds, that are discontinued on the north side of Peak, successively make their appearance. The Staiths beds, consisting chiefly of two thick beds of sandstone, parted by a bed of shale about 30 feet thick, first appear in the top of the cliff, not far from the village; and descending gradually, as the lowest shale sinks under the sea, they come down to the beach,

at the point which terminates the north *cheek* of the bay. These sandstone strata are succeeded by the Kettleness beds, consisting of 12 or 13 bands of ironstone, in seams or rows of nodules. The Sandsend bands follow, and then the main bed of alum shale, which occupies from 180 to 200 feet. The dogger at last appears at the top, and is surmounted by beds of sandstone and shale, with seams of coal. While these higher strata resume their places, the lower beds gradually sink beneath the sea, till the dogger itself descends close to the beach, opposite Gnipe-houe; where, as was formerly noticed, the sandstone beds acquire a vast thickness, and even the blue limestone of Cloughton wyke is found in the high ground, at some distance from the sea cliff. Beyond this point, the dogger and the alum shale rise again, and attain a considerable height in the cliffs of High Whitby and Saltwick; so that, in a few places, some part of the Sandsend or lias bands may be seen on the scar. Between Saltwick and Whitby, the dogger again descends to high water mark; but it rises again to the height of 60 feet, or upwards, before it arrives at Whitby harbour.

At the mouth of Whitby harbour, in the bed of the Esk, we come to the second great slip in these strata. The alum shale proceeds to the middle of the current, more than half way across the harbour, and there terminates abruptly, nothing but sandstone rocks being found on the other side. To what depth the strata on the west or north-west side of the harbour have sunk, cannot be very correctly estimated, especially as the sandstone beds are so variable, that it is difficult to trace the correspondence between those on the one side of the slip, and those on the other: but as the sandstone beds that come down to the beach at the battery appear to correspond, either with the highest beds of the east cliff, or with a higher portion of the sandstone strata there wanting, we can scarcely reckon the amount of the slip less than 100 feet.

In attempting to trace the progress of the break to the south and west, we find ourselves lost amidst the irregularities of the strata. It appears sometimes to follow the course of the Esk, and sometimes not. The strata, which form high cliffs at the mouth of the river, dip rapidly to the south or south-west on both sides; those on the right bank sinking or disappearing in Bagdale, and those on the left at Spital beck, a little further up. Immediately beyond the harbour, the strata rise again on both banks, and as the sandstone cliffs on the opposite sides appear to correspond, we see no vestige of the slip. Proceeding about half a mile further, we find the beds on both sides discontinued, or receding from one another, and the fine circular vale of Ruswarp, about half a mile in diameter, left in the midst. This vale, like the middle of the large vale of Pickering, seems to be a kind of centre of subsidence, the strata dipping towards it from every side, and rising all around it in the form of an amphitheatre. Here the strata on the south-east bank seem to have sunk deeper than those on the opposite side; for the blue limestone, that occupies so high a position at Gnipe-houe, is here found in the low ravines below Sneaton, as formerly noticed; and to what was stated on that subject we can now add, that it is found in a position still lower, in Cockmill wood, immediately below the mill-dam, and not many yards above the level of the sea.

The depression of the strata on the left bank appears to continue till we arrive at Sleights, where the beds rise to a great height, and the alum shale is discovered in a lofty position at Blue-bank, so named from the blue colour of the shale. The vale of Yburn dale, which opens on the left into the vale of the Esk, appears to have derived its origin, partly from the washing away of the strata, and partly from their subsidence: for though we find the aluminous beds, both at Littlebeck on the Sneaton side of the vale, and at Godeland banks on the Sleights side, they are more elevated at the latter than the former.

On comparing the elevated strata of Sleights and Eskdale side, with those of Woodlands, Newbigging, and Aislaby, on the right bank of the Esk, we see clear indications, that there must be a break in the strata, in or near the channel of the river, probably the continuation of the great break at its mouth. The thick sandstone beds of Aislaby are indeed at a very great elevation; but as they dip toward the south, like the strata on the left bank, were they continued across the valley in the plane of their general dip, instead of meeting the corresponding sandstone strata in the top of Sleights Brow, they would meet the alum shale in the slope of the hill. The same indications mark out the course of the break through the vale of the Esk, as far as Castleton; from whence it appears to pass through Commondale and Kildale to the plain of Cleveland; the line of the break corresponding with the division between the first and second ranges of our alum hills. On the left of this line, the hills, though somewhat broken by dales, rise to a great height, presenting abrupt faces towards the north, in which the aluminous strata are often seen at a great elevation; whereas the hills on the right are considerably lower, and their surfaces have a gentle slope towards the south, in which the strata consist of the higher beds of sandstone shale and coal, covered in some places with the blue limestone, and the strata above it. Perhaps in some parts of this line, particularly about Danby and Castleton, the slip may be as great as that of Peak, if not greater; though the subsidence is in the opposite direction.

On the north-west side of Whitby piers, the numerous contortions, cracks, and dislocations, in the strata of sandstone and sandy shale, give evidence of the catastrophe that has here occurred. These strata, which are near 100 feet high beside the battery, gradually descend, with some undulations, till they sink below the level of the sea, at the distance of about a quarter of a mile, leaving only an alluvial cliff. Before we reach Lector *nab*, they again rise to a considerable

height; but soon after descend to the beach, and the cliffs exhibit nothing but alluvium, till we get beyond Newholm beck. Between that beck and the foot of Dunsley lane, the dogger makes its appearance in the cliff, with the alum shale below it, but scarcely any sandstone above it. These strata gradually rise from the beach; but at Dunsley lane they are suddenly discontinued. Beyond Sandsend, they resume their course in the sea cliffs; and, as we find them here at such an elevation as they might be supposed to have reached, had no interruption taken place, we may presume, that whatever subsidences or breaks have produced the openings at the becks of East Row and Sandsend, they have not affected the general disposition of the strata. The two becks run parallel to one another for two or three miles, parted only by the high and narrow ridge on which stands the old castle of Mulgrave. The front of the ridge at Sandsend is alluvial, but we find the alum shale in it, not far above the village.

In the lofty cliffs beyond Sandsend, we not only find the alum shale and its covering of dogger rising to a great height, but a considerable thickness of the sandstone beds above them, often to the amount of 50 or 60 feet. On the scar below, the lias seams begin to appear, a little to the north of Sandsend alum house; from which circumstance we have named them the *Sandsend beds*. Beyond them the compact shale rises up like a wall; and, as has been noticed, the ironstone or *Kettleness beds* rise up at Kettleness point. At that point, the schistose beds rise to a great height; but the sandstone beds above them disappear, or retire backward.

Beyond Kettleness, the course of the strata is again interrupted, at the back of Runswick bay. Instead of continuing to rise beyond Kettleness point, the strata descend a little towards Hob-hole. There a great portion of the upper strata have been washed away, while the lower have partly subsided, at a small stream on the south side of the cave. The cave itself is in the compact shale. Beyond it, the whole

strata disappear, and the bay is skirted by an alluvial cliff, till we reach Runswick.

Here a very considerable break of the strata must have occurred, though it is concealed by alluvium; for instead of meeting in the Runswick cliffs the compact shale, as at Hob-hole, we find only the upper part of the main bed of alum shale, covered by the dogger, and by very thick beds of sandstone and sandy schist. The longitudinal slip, formerly mentioned, partly conceals the state of the strata at Runswick; yet we can see clearly, that they rise towards the north, or north-west: so that the back part of Runswick bay is, to a certain degree, another centre of subsidence.

Proceeding along the shore from Runswick, we find the strata rising with considerable regularity; the lias bands, the compact shale, and the ironstone bands, successively appearing below, while some of the upper strata disappear above. But on approaching the village of Staiths, at the opening of the valley or ravine of Dalehouse, we see the progress of the strata again interrupted. The sandstone beds above the dogger are lost; the dogger itself, after growing very thin, wears out; and the whole schistose strata above the sandstone bands are discontinued in the valley; so that the sandstone bands, which we have called the *Staiths beds,* may be seen at the village, forming the channel of Dalehouse beck, and appearing in the lower part of the cliffs. These sandstone beds, corresponding with those which sink at the north cheek of Robin Hood's Bay, make their appearance on the scar, a few yards to the east of Staiths.

Just before we reach that spot, we meet with a succession of breaks in the strata, indicating, that the valley which separates the second range of alum hills from the third, like that which divides the the first from the second, has been formed by a subsidence of the whole strata, as well as by a washing away of the upper strata. One of these breaks, not far from a singular bluff point to the east of

Staiths, is somewhat peculiar. It does not coincide with one or more of the cross veins, so as to make the fracture nearly vertical, but forms an irregular diagonal line, making an angle of about 50 degrees with the scar. The slope, or inclined plane, formed by the fracture, descends towards the west; and, as is usual in such breaks, the strata have sunk on that side. The quantity of the subsidence is about 30 feet; but in some parts, where there is a double fracture, the angular pieces in the middle have sunk only a few feet. The Kettleness or ironstone bands, appearing here, make it easy to observe the extent of the fracture. The same remark applies to another diagonal break, about 100 yards further west, where the strata have sunk about 6 feet, on the same side of the fracture. A little nearer the village, at the spot where the Staiths beds begin to appear, there is a vertical break of greater magnitude than either of these; but the subsidence is in the contrary direction, the Kettleness bands, and the coarse shale beneath them, having sunk down, while the Staiths or sandstone beds abruptly rise up. This rise seems to be greater than the amount of the subsidence at both the breaks now mentioned. The vale of Dalehouse bears marks of the irregularities, occasioned by these convulsions in the strata.

From Staiths the strata rise in an unbroken series to Boulby, the sandstone bands gradually ascending, while the beds or courses of the lowest shale rise up below, and the upper strata, which had disappeared beyond Staiths, successively resume their stations above, as the height of the cliff increases.

At Boulby we arrive at what may be called the back part of the aluminous strata; for as these strata have their general dip towards the south, and the cliffs there begin to run directly to the west, we seem to be behind the strata, in following their course in that direction.

The beds of the Boulby series proceed to the west by Rockcliff, where the Lofthouse alum works are carried on, maintaining their

regularity, and their great elevation, to a considerable distance: but, before they reach Lofthouse alum house, the upper strata are partly discontinued, while the lower gradually descend; so that, immediately beyond the alum house, the Staiths beds come down to the beach. From thence to Skinningrave, these beds are of a great thickness, forming a perpendicular cliff; but little or nothing of the higher beds appears above them.

At the deep ravine of Skinningrave, there is another interruption of the whole strata; probably occasioned by a partial subsidence, as well as by denudation or washing away. In Huntcliff, the lower beds rise to a great height, in the most northerly part of the cliff; but most of the upper beds are still wanting, or rather, are retired back from the front of the cliff, and concealed in the alluvial slope. In going round Huntcliff, we observe the beds on the west side of it descending with great regularity towards Saltburn, where they are covered with a deep alluvium.

It is proper to remark, that the apparent rising and falling of the strata, along the coast between Staiths and Saltburn, is more owing to the dip of the strata, than to any real undulations in their course: for, as they have a regular dip towards the south, we find them lower in the more southerly parts of the coast, as at Staiths, Skinningrave, and Saltburn; and higher in the more northerly parts, as at Boulby, Rockcliff, and Huntcliff. The last, being the most northerly point, is the place where the lowest shale acquires its greatest elevation; and had the cliffs been continued further in that direction, we might have found it rising still higher. There is, however, a real undulation at Skinningrave; the indentation of the shore at that creek being insufficient to account for the great depression of the strata.

Detached from Huntcliff, at the distance of about five miles, are the Redcar rocks, a large group of shelving beds, covered by the sea at high water, and very dangerous to mariners. They belong, as has

been already stated, to the lowest shale; and as they are more northerly than the foot of Huntcliff, they are a lower part of the series. Their separation from Huntcliff, however, has been occasioned, not by a mere washing away of the strata, but by some terrible convulsion; for instead of dipping to the south, like the strata at Saltburn, they dip rapidly to the west and north-west, presenting their broken edges to the east and south-east, in a long succession of parallel lines. Hence the rocks nearest to Saltburn are the lowest part of them, in geological position; and therefore, the most eligible spot for ascertaining by boring, what strata are the next under the aluminous beds, must be on the shore a little to the east of Redcar, opposite the first of these shelving beds. These rocks are named the *Salt Scars.*

To the west of Saltburn, the remainder of the third range of alum hills retire from the shore, forming the heights called Birdley moor and Bernaldby moor. These hills, of which the latter is higher than Boulby cliff, resemble the hills on the shore now described, having gentle slopes towards the south or south-east, and steep cliffs towards the north or north-west. These cliffs would be as precipitous as Rockcliff and Huntcliff, had the sea access to wash away the *debris* that crumbles down from their fronts; but that debris having accumulated at the foot of the cliffs, the hills are skirted even on the north with grassy slopes, more or less considerable. The aluminous strata, and the beds above them, crop out in the cliffs at various heights; but are generally so concealed by the debris and the alluvium, that their state cannot be examined with the same accuracy as in the sea cliffs. It is easy to see, however, in taking a general view of the strata of these hills, that they have been separated by some violent convulsion from the hills on the east, and that a vast break or subsidence must have taken place between them and the next range of hills on the south; for if the beds at Eston Nab, the highest part of Bernaldby moor, were continued southward in the plane of their dip, to the

Guisborough hills or Rosebury Topping, instead of meeting the corresponding beds in these hills, they would sink deep below their bases. In like manner, were the beds in Rosebury Topping prolonged in the plane of their dip, to Greenhoue Burton, or Battersby bank, they also would sink beneath the base of the latter; being on the opposite side of the great break formerly mentioned, that runs through Kildale, Commondale, and the vale of the Esk. The hills of Bernaldby moor and Birdley moor, with the hill of Skelton and some other small hills near them, may be viewed as vast detached masses; their strata having little or no continuity with those of the great chains to which they approach.

As there are inland cliffs in our alum hills, as well as sea cliffs, so there are also precipices on the coast which may be called *submarine cliffs*. We have repeatedly mentioned the rocky pavement of the shore, vulgarly termed *the scar*. That pavement, which skirts all our aluminous cliffs, stretching out into the sea to a considerable distance, and forming a broad margin at low water, is no doubt the lower part of what formerly constituted the cliffs of the coast, when the sea had not encroached so far on the land. Judging of the past by the present, we can easily see how this scar has been formed. The fronts of the cliffs, exposed to the united attacks of the waves, the winds, the rains, and the frosts, have gradually crumbled down; while their bases, continually moistened by the sea water, which serves to harden rather than to decompose, are preserved; being subject only to the very gradual wasting, resulting from the friction of rolling blocks. Now, in tracing the scar outwards, it is found in several places to terminate abruptly, presenting a steep face towards the deeper parts of the ocean: so that, were the waters of the sea removed, we should find another range of cliffs, more or less steep, encircling the present cliffs at some distance, while the scar would appear as a broad platform or terrace between them. The sea may indeed be expected to fill up

the inequalities in its bed, by what it washes away from the shores; especially on this coast, where the waste is so considerable; yet inequalities by no means trivial are still found in front of our cliffs.

The rock that lies before Whitby harbour, known by the name of *Whitby rock*, affords illustrations of these remarks. This rock, fatal to many a gallant ship, forms a kind of triangle, the base of which extends from Saltwick to the point of Whitby east pier, while the apex lies about N. N. E. of the pier head, at the distance of nearly seven furlongs. The angle formed at the pier head is somewhat obtuse, being a little larger than a right angle. The side extending from thence to the apex coincides with the line of the great break formerly mentioned. It forms a steep edge throughout its whole extent, especially towards the apex; for while the depth of water on the rock, when the tide is out, is only five, six, or seven feet, even towards the outermost point, the depth immediately on the west side of the rock is three or four fathoms about the middle of the line, and increases, towards the apex, to eight, ten, twelve, or even fourteen fathoms; nay, at a short distance out from the point of the rock, it reaches nineteen or twenty fathoms. Along the other side of the triangle, from the apex to Saltwick, the water deepens still more rapidly. Hence, the point of Whitby rock forms a submarine promontory, having submarine cliffs on the west and on the north-east, nearly equal in height to the cliffs on the west side of Whitby harbour.

As the sea water appears to preserve the rocks which it covers, and as the western edge of Whitby rock is in a line with the great break at the entrance of the harbour, we may presume, that the limits of that rock mark out nearly the original extent of the cliffs on the east side of the harbour, at the period when the present bed of the sea on this coast was formed, by the general sinking of the strata on the outside of the rock, and the partial subsidence of those on the west. On this supposition, we might calculate the time when the

catastrophe took place, could we ascertain the ratio of the decay of our cliffs. That ratio is by no means so great as some imagine. That the site of Whitby abbey, at its first erection by Lady Hilda in 658, was a mile from the sea, as asserted by some writers, is a groundless fancy, resting on no authority whatever. The average waste of our cliffs, as far as it can be computed from facts within our knowledge, does not exceed ten yards in a century, and probably has not been greater for many centuries past. At a more remote period, when the whole force of the ocean was directed against the apex of the triangle, or against its base when it was very narrow, the waste would be vastly greater, especially as the strata might then be softer. Making allowance for this difference, our calculation may easily carry us back to the era of the deluge, as the time when the cliffs of the promontory on the east side of our harbour, coincided with the outline of the submarine cliffs on the edges of Whitby rock.

For the sake of future calculations, it may be proper here to repeat what we have stated in the History of Whitby (II. p. 775, 776), that the distance from the verge of Whitby east cliff, to the nearest part of the abbey, measured in the line of the transept, was found in 1816 to be exactly 680 feet; including 46 feet, which is the breadth of a hole, or old quarry, on the margin of the cliff. The distance from the middle of the outer court gate of the hall of Charles Cholmley Esq., to the verge of the cliff, taken in a line with the old cross, is 714 feet.

Taking our leave of the aluminous beds, we now come to the last member of the strata of our district; which may be called

RED SANDSTONE WITH GYPSUM.

As the junction of the red sandstone with the aluminous beds is concealed by a deep alluvium, we cannot say with certainty, that the one immediately succeeds the other; yet, as the lowest shale with its

hard seams, may, like the Sandsend bands, be viewed as somewhat analogous to the lias beds; and as the latter are said to be succeeded by red sandstone in other places; particularly in Somersetshire, and in the north of Ireland;* we may infer, that our lowest shale is immediately followed by the red sandstone of Cleveland. Some think, that a considerable seam of coal exists under the aluminous beds between Redcar and Saltburn, as great quantities of coal are often washed up on the sands there, especially after a storm. The *sea-coal* of Redcar sands was well known above two centuries ago.† This coal, however, may be partly drifted from the mouths of the Tyne and the Wear by the flood tide, and partly supplied from the many wrecks of coal vessels on the Redcar rocks. No coal has been found in the red strata in the interior, though there are thin layers of coaly matter in the alluvial beds over it; yet it is possible, that coal may exist in the strata on that part of the coast, as it is found near sandstone in some other parts of Britain.

The title which we have given to this part of our strata (marked *p*) does not fully express its qualities. Red sandstone is indeed the most prominent feature in these strata; but their nature and colour are subject to great variations, similar to what may be seen in the extensive tracts of the same strata, occurring in several of the western and middle counties of England, and in some parts of Scotland and Ireland. In most places, this rock is a proper sandstone; in many, it is a kind of soft marl, so that it often obtains the name of *red marl;* and there are also instances where it becomes a species of limestone; while in a few places, a great proportion of clay enters into its composition, on which account it has also been termed *red clay.* Some specimens are highly schistose and micaceous; some, moderately schistose, and containing less mica; some, not fissile, but

* Geological Transactions, III. p. 165, 373, &c.

† See an ancient M. S. quoted in Graves's Hist. of Cleveland, p. 399.

breaking into numerous indeterminate fragments; and some, solid and massive. Like the alum schist, it usually increases in solidity as it descends. Its colour is sometimes a deep red, like the darkest red ochre; but the most common colour is a brick red, of various shades. This passes into a very pale red, and that again into yellow; which in many places, especially in the lower beds, changes to white, or yellowish white. These colours are not always in distinct layers, but are often clouded or blended together. The rock frequently contains hard bands of grey sandstone, and stripes or seams of a greenish blue substance, partly clay and partly lime. Calcareous matter is indeed so generally diffused through these strata, that most of their varieties effervesce with acids. The red and yellow colours are probably owing to a mixture of ferruginous or ochrey matter. Balls of ochre and nodules of ironstone appear to exist in some parts of the strata. We may add, that as the red rock is supposed to be indebted for its colour to oxide of iron, so the greenish stripes are considered as deriving their hue from oxide of copper.*

Owing to the thickness of the alluvium that covers the plain of Cleveland and the vale of the Tees, there are few places where these strata are exposed to view; and such places are almost all in the channels of the Tees and the Leven. The red sandstone may be seen in the bed of the Tees, at Croft bridge near Darlington, and at some distance to the westward of that bridge. It may be seen not far from the western skirts of the highest of our alum hills, in the bed of the Leven, below Crathorne; particularly at a mill a little below Foxton bridge, and at Middleton mill dam, near a mile lower. At the latter place, we find the yellow sandstone along with the red. The same strata appear further down, about Leven bridge not far from Yarm, and from thence to the Tees. The channel of the Leven, in most of

* Geological Transactions, I. p. 191, 192.

these places, runs between high alluvial banks. At the whinstone quarry of Preston, on the north-west bank of the Tees, opposite Barwick, a little below the junction of the Leven with the Tees, the sandstone is found of a white colour, or yellowish white; and is more hard and siliceous than in the places now mentioned.

We have not found the red sandstone itself in the eastern part of the plain of Cleveland; but an interesting portion of this member of the strata is exposed at the mouth of the Tees, at the foot of Lazenby fields, about two miles from Lazenby, and the same distance from Kirkleatham. It is a considerable bed of what may be called *argillaceous limestone*, or *calcareous claystone;* generally of a fine grain, and of a light olive or greenish colour, with reddish streaks or patches. The stone is much cracked, and is easily broken into irregular fragments; and being moderately hard, it might be termed *indurated clay marl.*

It is in this stratum that we find the GYPSUM, known to have been procured in this spot above two centuries ago, under the name of *plaster* or *alabaster.** The stratum occupies the lower part of the bank of the river, the upper part being alluvial; the height of the whole bank scarcely exceeding 15 or 20 feet. In tracing the bank from its north-eastern extremity, where it partly sinks, and partly retires backward, we find the argillo-calcareous bed gradually rising towards the south-west. At first we discern in it only a few thin strings of gypsum; but after proceeding 50 or 60 yards, we find it in the lower part of the bed, appearing in large branching veins. These veins are often found in large bundles, curiously ramified and interlaced; and as the interstices are filled up by the olive coloured stone, the rock has a singularly striped and mottled appearance. Some of the veins are two or three inches in thickness; and, in several of the

* M. S. quoted in Graves's Hist. of Cleveland, p. 400.

bundles, they are so thickly reticulated and crowded together, that the quantity of gypsum greatly exceeds that of the clay. Where the gypsum becomes plentiful, the upper part of the stratum in which it is imbedded begins to wear out, its place being occupied by alluvium; and the latter having been partly washed away by the river or the rains, the bundles or masses of gypsum are laid bare to a considerable distance along the foot of the bank, till the strata sink down, and the bank becomes wholly alluvial.

The gypsum, in the recent fracture, resembles fine white sugar; but its crystals are considerably larger, and many of them are of an oblong shape and very thin. It has in most places a reddish tinge; its oblong laminated crystals, when separated, are found highly transparent, like selenite; and the whole vein is translucent, especially near the edges. Many of the specimens are soft and friable, easily crumbling between the fingers; others are moderately hard and firm.

On the opposite side of the mouth of the Tees, at Seaton near Hartlepool, we find a very remarkable specimen of these strata. To the south and the north of Seaton, the cliffs are alluvial; but directly opposite that village, the strata rise up in the form of a ridge or arch, the highest part of which stretches out from Seaton towards the sea, nearly at right angles with the shore, but rather inclining towards Hartlepool; while the strata bend down on both sides of the ridge, dipping towards Hartlepool on the north, and towards Coatham on the south. On the shore at Seaton, the waves have worn away the higher part of the rocks, and displayed in the cliff a beautiful section of the party-coloured strata. In the middle of the arch, the upper strata are gone, and are replaced by alluvium; but we see what they have been, by tracing them on both sides of the ridge. The whole series may be stated as under:

1. A bed of sandstone, 6 feet thick; half of which is red, and the other half yellow, or yellowish grey.

2. Yellowish grey sandstone; 8 feet.

3. Another bed of the same; 5 feet.

These three beds are parted in some places by seams of blue clay.

4. Indurated marly clay of a greenish blue colour, containing a slight mixture of sand and mica; 7 feet. In this stratum are a few bands of sandstone, particularly one red band, which in some places is about 2 feet thick.

5. Grey sandstone, harder than No. 2 and 3; 2 feet.

6. Greenish blue marly clay, rather paler than No. 4, and containing a few beautiful crystals of pyrites; 1 foot.

If these green stripes are coloured by oxide of copper, these crystals may be presumed to be copper pyrites.

7. Red sandstone, forming the lowest part of the series here displayed; visible to the depth of about 10 feet.

The red strata are of a pale brick colour, very soft and marly in many places, but in others hard and sandy. Some of the most sandy specimens are highly schistose and micaceous. Thin masses, or imperfect seams, of greenish or blueish clay, are found here and there, imbedded in the red rock.

On the south side of the ridge at Seaton, the strata dip rather rapidly below the level of the sea; but on the north side, where there are some breaks and irregular bends, the red sandstone continues for a considerable distance along the shore; till, arriving at the commencement of the submarine bog formerly mentioned (p. 30, 31, 35), it recedes from the shore, and stretches out into the sea, forming another ridge, covered at high water, near the entrance of the harbour of Hartlepool. In some parts of the shore, the sandstone has a broken and mixed appearance, like breccia.

Besides these spots, where this member of our strata reaches the surface, we may notice others where it has been examined by boring.

In 1789, several trials for coal were made at Dinsdale on the Tees, between Croft bridge and Yarm. Some of the borings merely penetrated the alluvial beds, consisting of sand, gravel, clay, &c.; and entered a few feet into the red sandstone. Two of them, however, were carried to a great depth, the one to about 66 fathoms, the other to 74 fathoms; passing through various beds of red, white, grey, and blue rock; some of them soft, like clay or marl, others moderately hard, and a few very hard. These last were found running in bands in the softer strata. Gypsum was found in both borings, at a considerable depth; and in both it seemed to be connected with the blue seams. The last 32 fathoms of the deepest boring consisted almost wholly of white and grey sandstone, without any mixture of the red strata. A similar result was obtained from a more recent and much deeper boring, at Entercommon near Smeaton, about three miles to the south of Dinsdale, and on the south bank of the Tees. Here the borers penetrated to the depth of 223½ yards. The first 10 yards consisted of alluvial beds; the next 100 yards of red sandstone, in various beds, with a few bands of hard stone, &c.; and the remaining 113 yards consisted of red, grey, and white sandstone, including several very hard bands; the lowest beds being entirely grey or white, as at Dinsdale.*

At the deepest of the Dinsdale borings, viz. that of Woodhead on the north bank of the Tees, a sulphureous spring, like the Harrowgate spa, was found to issue from a blue stratum, lying under gypsum, at the depth of about 19½ fathoms. This spring, now termed Middleton

* The authors received this account of the Smeaton or Entercommon boring from J. Ash, the borer, employed by G. Allan, Esq., of Grange. The borings at Dinsdale were conducted by G. Rawlings, employed by the late General Lambton. The authors were favoured with the lists of these borings some years ago, by N. J. Winch, Esq.; who has since published them in the Geological Transactions, IV. p. 97, 98. The boring No. 1 descended only 10 fathoms, of which 2 feet consisted of red sandstone, and the rest of alluvium. No. 4, which reached 16 fathoms 2 feet, presents us with 15½ fathoms of alluvial strata, and only 5 feet of red sandstone.

spa, has lately acquired some celebrity, as a place of resort for invalids. A similar spring issues from the same strata at Croft bridge, on the south bank of the Tees, which is also a place of resort in the summer months.

It is natural to expect sulphuretted springs, in strata that contain so much gypsum, or sulphate of lime. The same kind of strata in Somersetshire contain also sulphate of strontian; and were our strata less concealed by alluvium, quantities of the same mineral might be found here also. It is said, indeed, to be found on the banks of the Nidd near Knaresborough; not, however, in the red sandstone, but in the limestone.*

The rock salt of Cheshire and Worcestershire is imbedded in strata corresponding with those of the vale of the Tees; but no brine springs have been discovered in our district. There is a salt spring issuing from the interstices of a basaltic vein, in the bed of the Wear at Butterby, two miles to the south of Durham; but it is too far from our red strata to have any connection with them.†

The deep alluvial covering of this member of our strata, prevents us from giving an accurate view of its extent. It appears, however, to occupy almost all the plain of Cleveland, with a considerable portion of the north bank of the Tees; and as it extends to the westward of Croft bridge, so it proceeds round the west skirts of our oolite hills, by Northallerton and Thirsk, near which are some gypsum quarries; and from thence it is supposed to advance further south into the vale of York.

The occurrence of the red sandstone in the plain of Thirsk, not far from the west front of the Hambleton hills, naturally leads us to conclude, either, that our aluminous strata which are of a vast

* Geological Transactions, III. p. 370, &c. IV. p. 196, 202, 214, 445.

† Ibid. I. p. 38, &c. II. p. 94, &c. IV. p. 24.

thickness at Cranimoor, and which sink under the north skirts of the Hambleton hills at Thimbleby, make a bend upwards, and run to a thin edge, on the borders of that plain, so as to allow the red sandstone to succeed them there; or else, that the red sandstone does not lie under the aluminous strata, as the next succeeding member of the series, but merely abuts against the broken edges, both of these strata, and of the strata over them, occupying the valleys in the form of what has been called an *upfilling*. It is certain, that the red sandstone appears in the latter form in several parts of England; particularly in the extensive plain, in which Appleby, Penrith, and Carlisle are situated; and in the vale of the Avon, near Bristol:* and it is not unlikely, that our red rock may be in the same predicament. It has not been found *under* our aluminous strata; nor, as far as we know, has it been seen *over* the magnesian limestone, which commences at Hartlepool. Besides, its position has no conformity, either with the one or the other; for the beds observed in Cleveland, instead of dipping towards the alum hills, so as to appear to run beneath them, rather dip in the contrary direction; and where the sandstone makes the nearest visible approach to the magnesian limestone, near the entrance of Hartlepool harbour, both are dipping towards one another, the limestone dipping towards the south, and the red sandstone towards the north; so that we may suppose them to meet each other abruptly under water, at the entrance of the harbour. It is obvious, however, that great dislocations of the strata have occurred at Hartlepool harbour, as at that of Whitby, the *Slake* appearing to be another centre of subsidence; and for this reason, and the entire concealment of the junction between the red rock and the strata adjoining it, both on the south and on the north, we cannot speak on this point with certainty. Should it be found, that the red,

* Geological Transactions, IV. p. 105, &c.; and p. 193-196, 205-209.

or rather, party-coloured strata, are not of the regular series of rocks, but merely fill up intervals between them, occupying deep valleys and extensive plains; in that case, such strata would bear some analogy to the alluvial beds, and form a kind of link, to connect these beds with the regular strata of the hills.—It is observable, that we have not found in these party-coloured beds any appearance of organic remains; though such remains occur in the strata on both sides.

The MAGNESIAN LIMESTONE of the county of Durham *(q)* is without the bounds of our district; yet, as it succeeds our red strata, we may briefly notice it. This limestone, commencing at Hartlepool, occupies the Durham shore, with a few interruptions, to within a mile or two of South Shields, where it leaves off abruptly, its northern termination appearing like a steep wall, but of no great height. From thence, its limits in the interior are traced in a south-westerly direction, by Bolden, Painshaw, Sherburn, Ferryhill, &c.; passing along the skirts of the coal district, and arriving at the Tees below Winston bridge, about ten miles above Croft bridge. The limestone that passes behind our district, by Ripon, Knaresborough, Tadcaster, Brotherton, and Knottingley; and that stretches to the south by Doncaster, as far as to Nottingham; is understood to be the continuation of the same rock; but we do not know that its continuity has been distinctly ascertained.

Numerous and interesting are the forms which this limestone assumes. Some of the most singular varieties occur near Sunderland. Of these we have already had occasion to mention the botryoidal or pisiform variety, which is a kind of oolite on a large scale, composed of clusters of crystalline globules. Another variety, no less remarkable, occurs in some rocks to the north of Whitburn. It contains numerous radiated crystalline cones, with their apices downwards, the radiations of which are so arranged, that when their bases are

exposed on the weathered surface of the rock, they present the appearance of the sunflower, having a circular disk in the centre, with a margin of petals diverging from it all around.

Even in the Hartlepool rocks, the limestone exhibits considerable diversity of structure and other qualities. In some places, it is decidedly oolitic, resembling the finer varieties of the oolite; in others, it is earthy: in some, it is soft, marly, and friable; in others, it is hard and compact. Some specimens contain quantities of loose marl, lodged in numerous minute pores or cavities; others abound with small holes or pores, which are empty. Most of the rock is of a dull yellow or buff colour; some part is of a dull grey; while a considerable part is white, approaching to the colour of chalk, which it also resembles in many of its other qualities. Indeed, the Hartlepool cliffs, though much lower than the chalk cliffs of Flamborough, bear a considerable resemblance to them; being parted by vertical fissures, into which the sea rushes violently, and forms a variety of caves and grottos, often supported by massy pillars. Several detached rocks stand in the sea, at a short distance from the front of the cliffs, and of the same height; and as the waves have hollowed out their bases into numerous arches, they present the romantic appearance of the ruins of an aqueduct, supported by huge pillars. The general dip of the rock is towards the south.

The magnesian limestone of Hartlepool does not abound with organic remains; yet a few shells may be found in almost all the varieties of the rock, and in some spots, especially in the white strata, the number is not inconsiderable.*

* For a further account of the Magnesian Limestone, and the strata that succeed it in Durham and Northumberland, see Mr. Winch's Paper on the Geology of these Counties, in the Geological Transactions, Vol. IV.—Mr. Winch is mistaken in asserting (p. 7), that the white oolitic limestone of Hartlepool "contains no shells or marine exuviæ:" the authors found in it both univalves and bivalves, especially the latter.

Having described all the strata, or flat rocks, of our district, it now remains, that we attend to a rock of a different nature, which intersects a large portion of them, viz.

THE BASALTIC DYKE.

This singular rock (marked *r*) crosses our alum hills in the form of a vein, intersecting the strata nearly at right angles. It is one of the most remarkable whinstone dykes in Britain, as it has been traced on the surface to the extent of 60 or 70 miles, and is in some places 70 feet wide, or upwards. It runs nearly in a direct line, north-west and south-east, from Cockfield Fell in the county of Durham, to Maybecks.

In several parts of its course, the dyke protrudes to a considerable height above the surface; as at the ridge called Parker's houe, in Glazedale; at a place in Lownsdale; and especially at Cliffrigg, and Langbargh, in Cleveland; where it forms a very prominent ridge, crossing the plain from the west side of Rosebury to the Tees, to which it proceeds by Nunthorp and Stainton. In other parts, it barely reaches the surface, or rises a foot or two above it; as in its course from Maybecks to Silhoue, and its descent from thence towards the Mirk Esk. In many other places, it does not reach the surface, being covered by alluvium, often to a great depth. Whether there be any spots where it is also covered by a part of the regular strata, remains to be ascertained. In a quarry at Whitley near Cullercoats, where there is an extensive mass of the magnesian limestone, detached from the great beds of the county of Durham, there is a similar dyke or vein, which intersects the coal and sandstone strata, under the limestone, but does not pass through the latter. It has been supposed that, in a similar way, our basaltic dyke passes under

the magnesian limestone, in its progress from Cockfield to the Tees.* This supposition, however, is by no means probable; for, whether we consider the red sandstone of the vale of the Tees as lying over the limestone, or as an *upfilling* between that and the aluminous strata, it is difficult to conceive, how the dyke should traverse the sandstone, without also intersecting the limestone, which is interposed between the sandstone and the coal district. Perhaps in a few spots, both in the alum hills and in the limestone, the vein may, as at Whitley, be covered by a portion of the upper strata; but the thickness of the alluvial covering, in the plains which it crosses in running north-west from the Tees, is sufficient to account for its rarely appearing at the surface, without supposing it to be covered by any part of the regular strata. At Preston quarry, where the dyke crosses the Tees, a little below Yarm, the alluvium is of such a thickness, that had not the channel of the Tees made its way through it, the whin dyke would not have been known to exist there.

As this dyke intersects the strata nearly at right angles, and as the dip of the strata in the alum hills is generally towards the south or south-east, the dyke in traversing these hills, *hades*, or inclines, to the same quarter. In general it runs in a straight line, N. W. and S. E.; or more correctly, W. N. W. and E. S. E: but it sometimes deviates from the rectilineal course. Among the alum hills we meet with some deviations more apparent than real, at the crossing of the valleys: for where the dyke descends from the heights, as it does below Silhoue, it seems to bend toward the north; because, as the dyke leans towards the south, the higher parts of it are further south than the lower. In other parts, however, there is a real deviation from the straight line. For instance, the line of the dyke at Preston quarry, instead of bearing in the direction of Langbargh ridge,

* This is the opinion of Mr. Winch. See Geolog. Trans. IV. p. 25.

diverges to the south about twenty degrees, and would, if prolonged, arrive at Battersby, Ingleby, or Greenhoue.

It is observable, that this large vein is thickest in the middle, and thinnest at the two extremities. At Cockfield, its width is but 17 feet; at the quarries of Preston and Langbargh, it is 70 feet, or more; at Silhoue, it is diminished to about 30 feet; and at Maybecks, its eastern termination, it seems to be scarcely any wider than at Cockfield. Thus the vein appears to swell in the middle, and to run to a narrow edge at the extremities. As such dykes, however, are justly regarded as large fissures or breaks in the strata, filled with basalt, the thickness of the dyke at the bed of the Tees and in the plain of Cleveland, may be otherwise accounted for; because, on the supposition that the vein has been filled from below, we may expect to find it widening as we descend; and consequently, it must be wider in the vale of the Tees, than in such elevated situations as Silhoue and Cockfield Fell. Yet our observations do not warrant us, to attribute the difference of width in this vein, solely or principally to a difference of depth; for it appears of a great thickness at Cliffrigg, where it is protruded to a considerable height, as well as at Langbargh quarry, which lies in the plain immediately below. We may add, at the same time, that wherever the ridge protrudes greatly above the surface, it occupies a much wider space than the mere thickness of the vein; for the higher portions of the ridge, having nothing to support them, have fallen down on both sides, especially on the south side to which the dyke leans.

The basalt in this dyke is disposed in blocks of various sizes and forms, generally oblong, and lying across the vein, parallel to one another, and sometimes approaching the form of columns, but with little regularity. One of the nearest approximations to the columnar form may be seen at Cliffrigg, where the blocks are often long, and appear like rude pillars, lying piled up horizontally. The blocks are

coated with a ferruginous crust; and the interstices between them are filled up with ferruginous clay, or decomposed basalt.

The rock is not uniform in its qualities. Most of it exhibits, in the recent fracture, a rough granular surface, of a dark blackish blue colour, with a number of shining specks, sometimes of the same colour, sometimes darker, and sometimes lighter. Very often the stone is quite black, with scarcely any tinge of blue. The shining crystals are frequently oblong and thin, like those in the blue limestone. We have not perceived among them any olivine or augite. The rock is remarkably hard, and supplies excellent materials for making roads; for which purpose it is quarried in several places. It seems to owe a great part of its hardness to the quantity of iron contained in it; from whence also the blocks derive their rusty coating. Some varieties of the stone appear like a mixture of clay and iron, and abound so much with the latter, that their recent fractures often exhibit a grey iron colour, which soon acquires a rusty hue, on being exposed to the weather. These specimens are not so compact as the black or blue basalt; but often abound with veins or crevices; many of which are filled, or lined, with calc spar, while others are empty. Similar cavities sometimes occur in the black basalt, containing crystals of calc spar; some of which are of a dull white colour, while others are highly transparent and beautiful, having laminated shining surfaces. Along with such crystals, we find in some of the crevices or small veins, a soft substance, consisting of very minute jet black grains, slightly adhering to each other, and having a glimmering lustre. When a portion of this substance is subjected to a red heat, the black colour is discharged, and it acquires a yellow brassy or pyritous aspect, the grains having a metallic lustre, and adhering more closely together. During this process there is no appearance of ignition. The substance is evidently a metallic oxide, and is probably the black oxide of iron, with a slight mixture of sulphur. Rhomboidal crystals of glassy calc spar are imbedded in it.

Along with the basalt, we find, in some parts of the dyke, that clayey substance known by the outlandish name *wacké*. It is usually of a greenish grey or light olive colour, with some ferruginous stains, especially in the seams or cracks, with which it abounds. Some of these cracks are filled with calc spar. It is generally rather soft and friable, but often occurs hard and compact. In short, it bears a strong resemblance to the indurated clay accompanying the gypsum at the mouth of the Tees, but does not like that effervesce with acids, and has a more coarse and earthy aspect. It is found among the blocks of basalt in patches, or irregular veins. A vein of wacké, three or four feet wide, occurs in Stainton quarry; where the authors also observed some of the most interesting varieties of the basalt.

As such dykes are known to be connected with breaks or slips in the strata, it is natural to expect, that in some parts of this long ridge, there will be found obvious marks of dislocation. This is the case at Cockfield, where the strata on the south side of the dyke are three fathoms higher than the corresponding strata on the north side. Had we access to examine the strata on both sides of the dyke, in its progress through our district, we might probably discover a number of similar phenomena, particularly about Cliffrigg, and at Maybecks, at both which places there are indications of breaks. At Maybecks, the dyke terminates abruptly on arriving at a stream, the channel of which seems to have been produced by a break, the ground on the east side being considerably higher than that on the west. We have discovered no traces of the dyke from thence to the shore; but as it bears somewhat in the direction of Peak, or more nearly in that of Haiburn wyke, it may be connected with the slip at one of these places. We have not perceived what effect it has had on the great break in the vale of the Esk, which river it crosses a little above Egton bridge.

It is well known, that where a basaltic dyke passes through

coal strata, the quality of the coal is changed; not only where it comes in contact with the dyke, but for several yards on both sides of it; appearing charred or burnt. This effect has been produced by our dyke, where it traverses the coal at Cockfield; the coal being reduced to a cinder, and the sulphur sublimed from the pyrites. Were the junction of the dyke with the coal seams at Maybecks, and other parts of our district, exposed, we might expect to witness the same phenomena. It would be desirable to know what effect the dyke has had on our alum shale; but we have not found any spot where the basalt and the shale are seen to come in contact. We have observed, however, that in its passage through the sandstone and the alluvium, the parting between the dyke and the strata which it traverses is commonly very distinct, so that there is no difficulty in detaching the basalt; and when it is removed, the sides of the vein appear lined with several coatings of a clayey substance, hard and whitish. In some places, this crust is smooth, like plaster or stucco; in others, we find the surface adorned with raised lines, curiously reticulated and ramified, in a manner analogous to the dendritical impressions, so frequently observed in the partings of sandstone and other rocks. This curious coating often looks as if it had been baked; while in some spots there are perpendicular markings, which seem to have been made by the motion and friction of the whole vein, upwards or downwards, rubbing against its sides. The substance is not a pure clay, but contains a mixture of calcareous and siliceous matter; numerous small fragments and grains of various kinds of stone being imbedded in the clayey cement.

GEOLOGICAL SURVEY

OF THE YORKSHIRE COAST.

PART II.

ORGANIC REMAINS.

PETRIFIED or preserved remains of the animals and vegetables of a former world, are so commonly met with in the rocks of almost all countries, that they have attracted the attention of the learned in every age. Herodotus, the father of Greek historians, mentions in his Second Book *(Euterpe)*, the existence of sea shells in the mountains of Egypt. Strabo, in the First Book of his Geography, speaks of petrified cockles, oysters, *pectines*, and other shells, observed in various regions remote from the sea; which statement he makes, not only on his own authority, but on that of more ancient Greek writers. Pliny, in his Natural History (Lib. xxxvii. c. 10), notices the *cornu ammonis*, the ostracite, and other petrifactions; and in another passage (Lib. xxxvi. c. 18) he mentions, on the authority of Theophrastus, an ancient Greek naturalist, the discovery of fossil ivory and petrified bones. Tertullian, one of the christian fathers, observes in his treatise *De Pallio* (c. 2), that the whole globe was once covered with waters, and that sea shells yet lodge in the mountains. Orosius, another early christian writer, speaking of the deluge, in the First Book of his History, mentions, as a proof of that catastrophe,

rocks abounding with oysters and other shells, in mountains remote from the sea.*

The petrifactions of our district have been noticed at an early period. The *jet*, which is found here in considerable quantity, and which is obviously a kind of petrified wood, is mentioned, as Camden observes, by Solinus and other ancient writers: and the Whitby *snake-stones* have an honourable place in the early history of our abbey, being connected with the fabled miracles of Lady Hilda.

It is only within these few years, however, that the nature of such remains has been properly investigated, and correct ideas of them have begun to be formed. The learned, at no remote period, were wont to regard them as mere sports of nature, produced by an occult *plastic power*. Mr. Charlton, in his History of Whitby, published only 42 years ago, after describing the petrified shells and wood found near Whitby, with what he calls petrified bones of men and horses, declares himself fully persuaded, according to the opinion of Dr. Lister and others, "that none of these petrifactions were ever real animals, or in any other state than that in which we now find them." Such notions are now universally exploded; and though men of science still differ as to the time and the manner in which these substances have been imbedded in their rocky habitations, all agree in pronouncing them to have been real animals or vegetables, at some remote era.

Viewed in this light, how interesting must these relics appear! They are the medals of the natural history of our globe, recording the changes which it has undergone, and setting before our eyes innumerable specimens of nature's early productions, a part of the animated stores with which the sea and the land were once replenished, at a period far beyond the limits of profane history. They carry back

* See other testimonies of this nature, in Parkinson's Organic Remains, I. p. 15, &c.

our thoughts to a time when the British Isles had no place, in their present form, on the map of the world; and when land and sea, mountains and valleys, rivers and plains, continents and oceans, must have been arranged in a manner completely different from what we now see. And while their extreme antiquity commands our veneration, their immense number, and inconceivable variety, with the beauty and perfection of many of them, impress us with sentiments of wonder, and may well excite us to admire and praise that infinite Creator, whose works in every age have been great and marvellous.

This district in particular seems like a vast storehouse, which nature, in primeval times, has filled with her choice and varied productions, embalmed and preserved by her own hands, to supply the latest ages with specimens of her ancient workmanship. Were all those relics restored to their pristine state of animation, our hills would teem with life: most of the calcareous strata would be found immense heaps of shellfish, piled up in countless myriads; while the aluminous beds would swarm with living creatures, in an endless diversity of forms and sizes. Even our vegetable remains, were they to experience such a resurrection, would be sufficient to replenish large forests, and to deck many a lawn, and many a mead, with verdure and beauty.

It would be vain, therefore, to attempt giving a complete list of all the *species*, or even all the *genera*, of the petrified animals and vegetables of the district. We can only present a general account of them, beginning with the least animated kinds, and proceeding upwards in the scale of life.——We begin then with

VEGETABLE REMAINS.

In describing the alluvium, we have noticed the decayed wood and other vegetables, found in the bogs of this district, where vast

quantities of such materials have been preserved for a number of ages. Besides these vegetable remains, contained in the alluvial beds, there are others of a more ancient date, which occur in the regular strata, and which are both abundant and various. They abound most in the sandstone, the ironstone, and the different kinds of shale.

Petrified plants, or impressions of the leaves and stems of plants, are very numerous in the shale that lies over the coal seams; as is the case in all coal districts. Some of these plants are ferns, others are reeds; but there is a confused mixture of a great variety of vegetables; some small, others large; some with minute and delicate leaves, others with broad and spreading foliage. There is a strong analogy between the shale containing these impressions or petrifactions, and the bog earth containing preserved leaves and plants. In both, the vegetables are confusedly mixed, and commonly very imperfect; and in separating the laminæ of both, we discover new specimens in every new seam or fracture that is laid open. In the bogs, however, the plants are of the kinds now growing in the British Isles, which is not the case with the generality of those occurring in the shale. On this account, and owing to the imperfect and friable state of the plants in the coal shale, it is difficult to assign them to their proper genera and species. In most of the specimens, the substance of the plant seems to have been changed into a black coaly matter. Some of them are impregnated with pyrites.

Remains of plants are found in other kinds of shale, as well as in that immediately over the coal. The authors discovered seeds of vegetables, apparently seeds of a kind of rushes or reeds, imbedded in what they have called THE SECOND SHALE, near Kirkham priory. These seeds are not petrified but merely preserved; being in a soft and rather pliant state. Their colour is brown or rusty; which is also the colour of some imperfect remains of leaves, found along with them. Some thin bivalve shells also accompanied them.

In some of our ironstone seams, particularly in the cliff at Saltwick, vegetable impressions are very common. The plants are often larger than those in the coal shale; though in both there is a mixture of plants of various sizes and kinds. The impressions in the ironstone are usually better defined, and, from the hardness of the stone, are more easily preserved than the specimens in the shale. The substance of the plant is here also generally blackish and bituminous, though impregnated with iron. The stems, leaf-stalks, middle ribs of the leaves, and other thicker parts of the plants, have undergone, in most specimens, a double transformation; having been converted into a sparry substance, partly black and partly whitish, which has been subsequently dissolved, and is now found in the form of a fine powder, retaining the same colours. The mixture of the black and white parts presents a curious appearance, the black exhibiting numerous cracks, both longitudinal and transverse, as in charred wood, while the white fills up these cracks. In several instances, the spar has not been decomposed, but remains in its original crystalline state.

Similar petrifactions occur in the sandstone, but in less quantity. The best vegetable impressions are in the harder beds of sandstone, particularly some of the crow-stone beds; but, as may be expected, we seldom meet with such delicate and well defined impressions in the sandstone, as we see in the ironstone or the shale.

If we suppose, with some authors, that the beautifully ramified substances in our moss agates, have been real vegetables, which, by some unknown natural process, have been enveloped by a solution of flint, and preserved in their form and colour while it has crystallized around them,—we shall find here another class of vegetable remains, much more delicate than those now mentioned. Great numbers of these moss agates, or jasper agates, as they are also called, are washed out of the alluvial cliffs, in nodules of various sizes, generally

rounded; and are found on the beach in various parts of the coast, particularly between Whitby and Sandsend, on the Scarborough shores, and especially in Filey bay. The mosses appearing in these stones are of various colours, among which yellow and greenish grey are the most predominant. Many of them, when shewn in polished sections, are of such extreme delicacy and beauty, as no pencil can imitate.

It may be fairly questioned, however, whether any of these ramified substances have been real mosses. Similar appearances are often seen in the mineral kingdom, in cases where no vegetable substance is present. Not to speak of the numerous dendritical impressions in the seams of sandstone, chalk, and other rocks, we know that metals, or metallic solutions, assume, under certain circumstances, beautiful arborescent forms; of which we have a striking example in zink. Metallic solutions, blended with silex, may have produced all those delicate and richly coloured ramifications, by which our moss agates are distinguished.

The seven Figures in Plate II, and Figure 1 and 2 of Plate III, are correct delineations of a few specimens of the petrified plants, occurring in the coal shale, the ironstone, and the sandstone. All the specimens in Plate II are from the Saltwick ironstone, except No. 4 and 5, which are from the shale at Fryop coal pits. No. 1 of Plate III is from the Castleton coal shale, and No. 2 is from the sandstone above Sandsend alum works. Most of these petrifactions are evidently ferns, a class of plants which, from the hardness of their stems and leaves, are the most likely to be found in this state.

Of the plants here figured, No. 7 of Plate II is the only one that appears to have its recent analogue in this district. It is an imperfect leaf of the *scolopendrium*, or *hart's tongue*. An entire leaf is not often met with; but on comparing different specimens, some of which contain the stalk, others the point of the leaf; and some

shew the upper surface, others the under; we observe the correspondence of the petrified with the recent plant.

Among the plants not figured, for we could only give a few specimens, we have found the *ruta-muraria*, or *wall-rue;* with some other small leaved ferns, one of which appears to be the *ceterach*, while others may be assigned to the *polypodium* family. The best impressions of these plants are in the Saltwick ironstone.

No. 3 of Plate II is probably an *asplenium:* it approaches the *ruta-muraria* in the form of its leaves. No. 4 is another delicate leaved plant, but evidently of a different species. No. 1, which is reversed on the Plate, is very distinctly marked, having sessile, striated or nerved, oblong, recurved leaves, or leafets, placed alternately. It appears to be a fern. No. 5 may also be a fern, though it has something of the tufty appearance of some of the spiked plants belonging to the *didynamia* class.

Figures 2 and 6 of Plate II appear to belong to one plant; the former being a leaf, somewhat imperfect, and the latter the head or fruit of the plant. The head is nearly entire, though depressed on the upper surface, and resembles that of the artichoke, *cynara integrifolia*, the covering, or calyx, consisting of numerous lanceolate and striated leaves, partly lying over one another, though not quite in the imbricated form. The correspondence of the leaves of the calyx, and some broken leaves adhering to the head, with the leaves or leafets in Fig. 2, appears to mark them out as belonging to one plant. Some imperfect stalks, in a decomposed state, which may have also appertained to this plant, have been found in the same place. In Fig. 6, may be seen the spot where the stalk has been attached to to the head. The leaves of this singular plant often occur in the ironstone at Saltwick; but no other specimen of the head is known to have been found. The lanceolate leaves, or leafets, are often larger than those in Fig. 2; and generally present a convex surface,

the middle of the leaf being raised. In correspondence with this, the under side of the leaves of the head are depressed in the middle.

Fig. 1 of Plate III has the bushy aspect of the *hippuris*, or *mare's tail;* but is more likely to be a fern. Fig. 2 appears also to be a fern. Some specimens in the sandstone bear a great resemblance to the *pteris aquilina*, or common *brake.*

Some of the harder sandstone beds, above the alum rock, particularly some whitish beds, abound with markings of roots, and slender branches, of trees or shrubs. Few of these afford very interesting specimens, especially as the woody substance is generally gone, and only a cast of it remains in the rock, covered with a thin blackish crust, or bark.

Fig. 3 is a specimen of one of the most singular vegetable petrifactions, occurring in this district. It is part of a kind of reed or cane, found in a sandstone bed at the top of the cliff opposite High Whitby. The bed is four or five feet thick, resting on a bed of bituminous and clayey shale, in which there is a coal seam. Over the sandstone is a stratum of sandy shale. The reeds, which are very numerous, are arranged parallel to one another, and perpendicular to the plane of the strata; as if they had grown on the spot, previous to the time when the strata acquired their present dip, with their roots in the clayey shale below.

The stalks are from an inch to near two inches in diameter, and are divided by joints placed at intervals of from two or three inches to eight or nine. At each joint, as may be seen in the Figure, there is a brown striated band, similar to what we see in the *equisetum*; and this band has been fringed, though it is only in some instances that we can discover the fringe diverging from it into the surrounding stone. From above each joint, a lateral branch has proceeded; and this takes place alternately, so that where a branch has gone from the right side at one joint, it issues from the left at the

next. Yet in many instances, we find more than one branch at each joint. These lateral branches, which have been very slender, are rarely seen in the stone. The bands are frequently double, divided by a cross line in the middle. On examining the lower part of the bed, we find several portions of the roots, the joints growing shorter and shorter, till we find nothing but a mass of bands, which gradually diminish in size, the reed tapering away. These roots, or tapering ends, are generally black, or very dark brown. At the upper part of the stratum, the reeds are broken off abruptly, on meeting the sandy shale. According to the proportions of the stalks and their joints, they must have risen to a great height in their entire state.

On comparing these petrified plants with a recent specimen of the *sugar-cane, saccharum officinarum,* we perceive so striking a resemblance, both in size and form, that we may consider our canes as of the same family, if not of the very same species.

These reeds occur also in the Stainton cliffs, about the same distance above the alum rock. Their matrix at that place is rather whiter and harder than at High Whitby, being something of the crow-stone. They may probably be discovered at a similar height in the strata, in several other parts of the district.

Reeds of the same kind are found in the sandstone accompanying coal, in other parts of Britain; as at the coal pits of Alloa in Scotland. In these places, the stalks are almost always found compressed and flattened; but in our district they are for the most part in their natural cylindrical form. Yet a few of the canes at High Whitby are found flattened; and a few are lying across, in an irregular manner, instead of being in the usual upright posture. We have only to add, that though the line of separation between each cane and the surrounding matrix is very distinct, yet there is no appearance of internal organization in the reeds, the inside consisting of the same

sandstone as that which is without. Hence we may regard them as casts, rather than petrifactions.

This last remark applies to another class of vegetable remains, found in the sandstone, and sandy bituminous shale,—those cylindrical fossils, which have their surfaces adorned with curious markings, disposed in rows in the quincunx form. These markings correspond with the impressions made by the leaves of trees of the pine family; the roots of the leaves, especially in the young branches of such trees, making rows of indentations, placed in the same style, around each branch. Specimens of this kind have been found in the sandstone, several feet in length, and displaying in the cross section a mark in the centre, corresponding with the pith of the tree. The indented impressions are always alike in the same specimen, but vary in different specimens. Two fragments are given as examples, Plate III, Fig. 4 and 5: the former of which is from the sandy shale, or coaly sandstone, connected with the coal; the latter, with the arrow-head markings, from the hard sandstone, or crow-stone. Several other varieties occur. In some, the indentations consist of minute circles, each having an elevated point in its centre; in others, the surface is beautifully reticulated and dotted, having elegantly waved lines, like those of No. 4, running between the rows of indented marks.

Nodules resembling nuts or fruits are not uncommon in our strata, especially among the aluminous beds; but real petrifactions of fruits are rarely met with. Figure 7 of Plate III is a petrified nut of a singular kind. It is from the ironstone nodules occurring in the sandstone, in the cliffs on the west side of the battery at Whitby; where it was found by Dr. Campbell. The crust, or shell, is of hard ironstone, of a dark reddish brown hue, and marked with high longitudinal ridges, finely striated. The nucleus, or kernel, which is laid open at the top, where the shell has been broken, consists of a soft pale grey earth, or ochrey clay.

Petrified *wood* occurs in a number of our strata, as in the sandstone, the ironstone, the dogger, and especially the aluminous beds. Large portions of trees, some of them with the appearance of roots, have been found in the sandstone; but smaller pieces of wood are much more common. Very often the wood in the sandstone is in the state of charcoal, some of the strata containing an infinite number of fragments of charred wood, of various sizes. Beds of this description may be seen between Cayton mill and Scarborough, and especially among the sandstone strata immediately over the alum rock, both on the shore and in the interior.

In the aluminous strata, petrified wood is found in abundance, and in a variety of forms. Fig. 6 of Plate III exhibits a small specimen, containing a knot, from whence a branch has issued. The grain of the wood is very discernible, as it usually is in what we find in the alum rock. Sometimes the wood contains calc spar, disposed in veins or cracks, after the form already noticed as occurring in the stalks of plants in the Saltwick ironstone; the wood being rent or cracked both longitudinally and transversely, as in charred wood, and the sparry matter filling up all the cracks. Very often, instead of spar, we see pyrites occupying the fissures; and a great proportion of the specimens in the alum shale have more or less of a pyritous crust. In many instances too, siliceous matter is distributed through the veins or cracks, and it is not uncommon to find specimens highly siliceous, or completely agatized. In almost all the siliceous specimens, however, and in a great part of the other varieties, whether calcareous, pyritous, or argillaceous, the wood has no appearance of having been charred, and the stony matter, instead of being distributed in veins or cracks, is diffused through all the pores and interstices of the woody fibres, with which, especially in the siliceous petrifactions, it is intimately combined. It is not uncommon to find all or most of the varieties, now mentioned, in the same specimen;

some parts of a petrified tree, or large piece of wood, being calcareous, others siliceous, others argillaceous, and others pyritous; or, instead of occupying different parts of the specimen, the petrifying substances may be found blended together.

In many instances, we find portions of the wood not petrified, but preserved; being in a soft friable state, like common decayed wood, and retaining its inflammable quality. Such preserved portions are found in almost all the varieties above mentioned, not excepting the hardest siliceous specimens; one part of the same piece of wood being petrified, while another is merely preserved. Sometimes we also meet with preserved pieces in a detached form, imbedded in the alum shale by themselves. Instances also occur, in which only the fibrous part of the wood has been petrified, the sap vessels and pores being left open. In some cases too, especially where the trees are of a considerable size, the bark is found as a crust, enveloping the ligneous matter, as when the tree was growing; but in most specimens, no vestiges of bark are to be seen. We do not often meet with trees of a large size, most of the wood being found in fragments, and much of it in a bruised or compressed state: yet round trunks of trees, twelve feet long and upwards, and a foot or more in diameter, have occasionally been discovered at Whitby; and at Sandsend, Rockcliff, and other places. The colour is generally a blackish brown or grey, but it is often yellowish, or light grey; varying according to the petrifying substance. A transverse section of one of the largest trees is generally very interesting, displaying the concentric zones, or annual growths, together with the veins of pyrites and other substances.

We have already hinted, that *jet* is only a variety of petrified wood. That this is the fact, must be obvious to every naturalist who examines the state in which it appears on our coasts. Sometimes we find, in the same petrified specimen, one part siliceous,

pyritous, or calcareous, and another pure jet; or even one part preserved wood, while another is real jet. Sometimes a crust of excellent jet, an inch thick, is found on the outside of a log of pyritous or siliceous wood. Even the pieces of jet which occur by themselves all betray their ligneous origin. They are in the form of flattened branches or trunks of trees; or compressed fragments, like pieces of the common petrified wood; and the outer surface is always striated with longitudinal markings, like the grain of wood, while the transverse fracture, which is conchoidal with a resinous lustre, displays the annual growths in elliptical zones; which are more or less flattened, according to the degree of compression which the wood has undergone. The same facts are also exhibited in the longitudinal fracture. Besides, we often observe branches diverging from the principal mass; and on taking up such specimens, their bed is found to be the exact impression of the trunk of a tree with its branches. The larger masses are about ten or twelve feet long, eighteen or twenty inches broad, and only from an inch to two inches thick. Their great flatness is a striking peculiarity. It would seem that, by one of those processes which have been carried on in nature's laboratory, the wood imbedded in the strata has been reduced to a soft pulpy state, and in that state has been compressed into flat pieces by the weight of the superincumbent mass. The flat surface, as might be expected, is generally parallel to the plane of the strata; which is also the case with the flat pieces of common petrified wood, especially the larger specimens, and even with most of the petrified plants. When a core of siliceous wood remains within the block of jet, it is only partly flattened; the silex having obstructed the natural process.

The electric property and beautiful black lustre of jet are well known. Within these few years, great quantities of it have been manufactured at Whitby and Scarborough into ornaments and trinkets

of various kinds; and several hundred-weights have been sent to Edinburgh and other distant parts, for the same purpose.

The principal repository of jet is the main bed of alum shale, but it is not limited to the aluminous beds. We found some of it in the *second shale* near Terrington, and it has been often found in the same bed at Malton. Even the sandstone sometimes contains it; though in that matrix it is generally brittle, and holds a kind of intermediate station between the best jet and coal. In the front of the cliff, on the north-west side of Haiburn wyke, is the petrified stump of a tree, in an erect posture, about three feet high, and fifteen inches across; having the roots, which are in a bed of shale, in the state of coaly jet; while the trunk, which rises in the sandstone, consists partly of common petrified wood, and partly of decayed wood, which has a sooty aspect.

The affinity between *jet* and *coal*, particularly what is termed *cannel coal*, is well known; and having considered jet as a particular modification of petrified wood, we would venture to pronounce coal another of its varieties. As we find specimens of petrified wood consisting partly of jet, so we also find not a few in which there is real coal, breaking into cubical fragments, in the usual form. This is the case, both in large blocks of petrified wood, and smaller pieces. The coal occurring in such specimens, whether imbedded in the alum shale or the sandstone, is not to be distinguished from that of the proper coal seams. We find also, in examining the latter, evident vestiges of trees or branches, betraying the vegetable origin of this most useful mineral; which is further confirmed, by our uniformly observing vegetable impressions in the shale that covers the coal seams.

As the blocks of petrified wood in our strata, are generally found lying flat, with their longest diameters in the plane of the strata, a number of such blocks, in the coaly state, lying together,

with branches and smaller vegetables filling up their interstices, would form a coal seam; and a large accumulation of such materials would constitute a bed of coal. We know not indeed, by what process nature has converted wood into jet, or into coal; but we are equally ignorant of the way in which wood has been transmuted into silex, or a mass of shells into limestone. Since however, we are sure, that the process has been conducted on a small scale, why not also on a large? The same power that converted a single tree into jet, might form an assemblage of such trees into a seam of cannel coal, or Bovey coal: and the same process that reduced a detached block of wood to the state of common coal, might produce, from accumulations of such blocks, the largest beds of pit coal. The quantity of the materials required is no obstacle in the way of this hypothesis; for if the stores of nature could furnish such prodigious quantities of shellfish, to fill our oolite and other beds, her magazines of vegetable matter, if in the same proportion, would more than suffice to replenish all the coal pits hitherto discovered.

Marine plants are not commonly found in a petrified state; yet the group represented in Plate IV, Fig. 9, may almost be affirmed to be of that class. It is a specimen of long cylindrical bodies, found in great quantities on this coast, bearing a striking resemblance to the stalks of the common *tangle*, and often appearing in pairs, as these stalks are wont to grow. Like these stalks, they have a brown coating; and the appearance of brown leaves among them, or of a brown substance that may have been formed of the leaves, strengthens the analogy. The cross section of the petrifaction has also, in some instances, a resemblance to that of the plant, displaying the same concentric zones; but the petrified bodies are seen, in some places, to run into one another, or to be connected by lateral communications, such as we do not know to exist in any species of the recent plant.

These petrifactions may be seen in their most perfect state, in a recess on the shore between Runswick and Staiths, from whence this specimen, Fig. 9, was taken. They lie in a kind of beds or seams, covering some of the bands of ironstone which we have named the *Kettleness beds.* They are found in similar situations in other parts of the coast. We also meet with them in the ferruginous sandstone of the Scarborough and Cayton shores, and in some of the hard sandstone beds at Filey Bridge.

The existence of iron in most places where these remains are found, may occasion some doubt as to their vegetable origin. It has been already remarked, that metallic solutions often assume arborescent forms, and we know that depositions of iron at chalybeate springs are sometimes curiously ramified, and that ferruginous matter frequently sinks down in clayey beds, where it hardens in the form of roots of shrubs: but the bodies now under consideration seem far too uniform in their size, shape, and arrangement, to admit the supposition of their having been produced in the same way. Besides, undoubted petrifactions of wood, and other vegetable substances, are often found impregnated with iron, or even imbedded in ironstone, the iron lending its aid in preserving them; and this has probably been the case in the present instance.

Some have described such bodies as *spongites;* but it is more likely, that they are the remains of marine plants. It is possible, however, as some of the sponges branch out in a similar way, and as sponges are found to grow among marine plants, that the petrified substances, found in the situations now mentioned, may consist partly of both.

Passing from the vegetable to the animal kingdom, we meet, on the confines of the latter, with that singular class of creatures known by the name

ZOOPHYTES.

Zoophytes, or *animal plants*, as the term denotes, hold a kind of intermediate place between animals and vegetables; partaking of the characters of both, and linking them so closely together, that it is difficult to determine where vegetation ends, and vitality begins. Previous to the last century, they were classed with vegetables; but the more accurate researches of modern times have established their claim to be ranked among animals.

When we consider, that this order of animals comprehends the whole of those hard, bony, or rocky substances, denominated *corals*, it is natural to expect, that a great quantity of them should be found in a fossil state. The *sponges* and *alcyonia*, which are for the most part soft and gelatinous, are also supposed to be found petrified in considerable abundance. It is, however, very unlikely, that any animals of that kind are really discovered in a fossil state, except such as have a coriaceous and firm substance. When we recollect, that the parts of animals and vegetables usually found petrified, are such as are naturally hard; as the shells of testaceous and crustaceous animals, the bones and teeth of fishes and quadrupeds, the ligneous parts of shrubs and trees, with the hard stalks and leaves of ferns and reeds,—it will require strong evidence to convince us, that fleshy, pulpy, or gelatinous substances, may be found transmuted into stone. Who would expect to find a petrified *medusa*, or a petrified snail? It is more than probable, that a large proportion of what are called *alcyonites*, may be particular kinds of coral; and that a great part of the supposed *spongites*, may be either corals, or petrified stalks of the

harder kinds of *algæ*, and other marine plants, such as those represented in Plate IV, Fig. 9.

The corals are divided into various genera, as *tubipores, madrepores, cellepores,* &c.; differing from one another in their internal structure or organization. Several varieties of them are found in the regular strata of the district, but a much greater number in the alluvium.

Tubiporites, or petrified tubipores, occur in the alluvial beds, chiefly in nodules of limestone, which are washed down by the rains, and found among the gravel on the beach. The Scarborough Catalogue of Fossils enumerates four different species as occurring on the coast; one of which is the *tubipora musica,* resembling organ pipes, and another the *chain coral.* A few others have been noticed by the authors on the Whitby shores, and more may yet be discovered, as there is an almost endless variety of fossils in the alluvium. We have not observed any specimens in the regular strata. This kind of coral is composed of erect hollow cylindrical parallel tubes, commonly joined together by small cross tubes.

Madreporites, or *star-stones,* distinguished by their stellular conformation, are a beautiful class of corals, frequently met with in this district. Numbers occur in the regular strata, and many more are found on the beach, in limestone nodules that have fallen from the alluvial cliffs. They display great variety and beauty, particularly in their polished cross sections.

The madrepores are distinguished into simple and compound, the former shewing only one star, the latter an assemblage of stars. Both are found in our strata, particularly in the oolite and the chalk.

Many of the simple madrepores bear a great resemblance to some kinds of mushrooms; while others resemble pears, and other fruits; rising up from a stalk, by which they appear to have been

fixed, generally swelling out, or spreading, either suddenly or gradually, and having a depression or cavity in the upper surface.

A few specimens of simple madrepores, partly from the oolite, and partly from the chalk, are figured in Plate IV, No. 1, 3, 4, 5, 6, 7, 8.—No. 8 is a large and beautiful star, resembling a flower; and is supported by a short stalk. It is from the oolite at Malton; and, like most other madrepores in the oolite, consists partly of lime, and partly of flint or chert. The stalk, as in the other specimens, shews the longitudinal edges of the *septa*, or internal lamellated partitions in the madrepore. The upper edges of the same septa, diverging from the centre, give the fossil its stellated aspect.

No. 5, which is from the chalk, bears a considerable resemblance to No. 8 in the upper surface; but it has no stalk, except a small protuberance below, from whence the septa diverge to the circumference, as on the upper surface; which last has a slight depression in the centre. The edges of the lamellæ are less conspicuous than in No. 8, their interstices being more filled up with calcareous matter. It resembles in shape the *madrepora porpita*, or shirt-button madrepore.

No. 4 is an elongated turbinated madreporite, from the Malton oolite. The upper part terminates in a kind of cup, and the whole fossil resembles a collection of cups, placed one within another, the lowest ending in the stalk. A section of the same fossil is given in Parkinson's Organic Remains, Vol. II, Plate IV, Fig. 8. The edges of the lamellæ are visible in the stalk, but not prominent.

Nos. 1, 3, 6, and 7, are specimens of what are usually called *alcyonites*, being regarded as petrified *alcyonia*. Numbers of these fossils are found both in the oolite and the chalk; appearing in various forms; some being like mushrooms, as No. 7; others resembling pears or figs, as No. 3; and others as No. 1, and 6, partly fungiform, partly in the shape of a trumpet, being furnished with a

very long stalk. Others have an oblong oval form, and bear some resemblance to almonds. The appearance of such fossils has often made them pass for petrified fruit, or petrified *fungi;* and indeed we could as soon believe, that fruits and mushrooms might be converted into stone, as that soft gelatinous *alcyonia* could undergo this transmutation.—No. 3, which is from the oolite, and highly siliceous, displays traces of the longitudinal edges of the lamellæ; though they are detected rather by their dark colour than their prominency. The starry disk, though obscure, may also be perceived. Many fossils of the same shape are found in the chalk, some of them of a considerable size; and in several of them little or no trace of the madreporean structure can be seen. Some of them are in the shape of a cucumber. They all appear to be varieties of madrepore, or at least of coral.

Yet No. 1 and No. 6, which are both from the chalk, and are obviously the same fossil in different states, are not of the same species as No. 3, and probably were never crowned with a star; their upper surface, which is depressed in the centre, exhibiting a multitude of pores; several of which are open in No. 6 to a certain depth, but which are all filled with silex in No. 1. In this specimen, as in many others, there are numerous warty excrescences, both on the disk and on the lateral surface. The edges of the lamellæ, if these two fossils have had any, are entirely concealed.

Figure 7, which is from the oolite, and is remarkable for its fungiform shape, has the same porous upper surface as we find in No. 6, but the lateral edges of the lamellæ are very distinct and prominent: traces of them may even be seen on the border of the disk. The deeply channelled surface under the disk, together with the shape of the latter, and of the stalk, makes the fossil bear a very striking resemblance to a mushroom. It has no doubt, like other madrepores, derived its form from the labours of the animals called *polypes;* and

had not their operations been accidentally directed to one side, in preference to the other, its disk might have been round, as in the other specimens figured. The pores are not placed promiscuously, but appear to run in rows between the lamellæ.

Some specimens nearly in the shape of No. 8, have their disk in the form of a cup. Others, which also terminate in a cup, have not a short tapering stalk, but swell out in the middle, like a turnip, or a boy's top. In some of these fossils, found in the oolite on Langton Wolds and near Malton, the edges of the lamellæ have a curious striped appearance, being alternately thick and thin; a circumstance sometimes observed in other varieties of these madreporites.

Next to the petrifactions now described, we may notice those madreporites which present the appearance of an accumulation of simple madrepores, heaped one above another, or rather growing one out of another. From the disk of one, two or three others arise, each terminating in a single star; and considerable clusters thus formed, are sometimes met with in the oolite, and in the alluvium. With these we may notice the branched corals, which also belong to the oolite, and are found near Malton and at Kirkby Moorside. Some of them have slender branches, about the size of a quill; in others, the branches are from half an inch to near an inch in diameter. Two, three, or even four branches, may be found diverging from one stalk. The branches are often striated, the edges of the lamellæ appearing around them; and each, when entire, terminates in a single star. Some specimens of branched coral, found in the Malton oolite, resemble that figured in Parkinson's Organic Remains, II, Pl. V, Fig. 5; but without the cross bands: and coincide exactly with the recent coral represented in the Philos. Trans. (Abridged) Vol. X, Pl. V, Fig. A.

Most of these branched corallites, found in our oolite, are highly crystalline or sparry; so that their cross fractures shew little of their internal organization. In the fungiform kind and others above-mentioned, there is generally very little spar; the septa or lamellæ being often highly siliceous, and the interstices filled with a less compact matter, chiefly calcareous. Such fossils are frequently dipped in acid, to dissolve the calcareous matter adhering to them when recently found, and display the edges of the lamellæ more fully. When they have passed through this process, their surfaces appear finely glazed.

But the most beautiful of our fossil corals are those which present an assemblage of stars on their upper surface; and especially those in which the stars are connected into a system, and disposed at regular distances. Of these, one of the most common, and at the same time the most beautiful, is that of which a specimen is given in Plate IV, No. 2. It corresponds with the recent *madrepora ananas;* having the stars arranged in hexagonal or pentagonal compartments. Each star is deeply depressed on the disk, and has usually a minute cone, or *papilla*, rising in the centre, and is inclosed by an elevated circular margin, on the outside of which are fine diverging *striæ*, filling up the rest of the hexagonal compartment. These minute stripes are not represented in the figure; in which also, the hexagonal *septa* are made much more distinct than they are in the fossil. The specimen is from the oolite at Helmsley, and consists chiefly of chert, or rather of calcedony. Madreporites of the same kind occur at Malton and other places. Polished sections of them exhibit a beautiful net-work, which is well represented in Parkinson's Org. Rem. II, Pl. V, Fig. 1.

Another beautiful madreporite of this family also occurs in the Malton oolite, bearing a considerable resemblance to the last, but having neither the elevated circle, nor the central *papilla;* the *striæ* formed by the edges of the *lamellæ*, proceeding from the centre, which

is somewhat depressed, to the hexagonal *septa*. The stars of this fossil nearly correspond with those of the specimen figured in Parkinson's Org. Rem. II, Pl. V, Fig. 3; except that they present no appearance of concentric circles. In a specimen of this kind from Malton, the stars are very distinct on the upper surface, which consists of chert or calcedony to the depth of about a line; but the interior of the fossil displays no vestiges of organization, being composed of calc spar, in crystals of a singular form, each crystal being nearly discoidal, with a sharp edge.

Did our limits permit, we might notice a great many other madreporites, occurring in the regular strata and in the alluvium. The latter contains the greatest variety, chiefly in nodules of limestone, which are often washed down from the cliffs, and are found rolling on the beach. Several of these are susceptible of a fine polish, displaying beautiful sections of the starry columns. In some of them, the stars are not arranged into a system, so as to occupy the whole matrix in regular compartments, but are scattered or straggling. Even in some of these, however, we may perceive great beauty; as in a specimen which the authors lately found at Sandsend, having the rays of each star crossed by concentric circles, as in the Transylvanian fossil figured in Parkinson's Org. Rem. II, Pl. V, Fig. 8.

The *madrepora arachnoides*, or spider-stone, and the *lithostrotion* or basaltiform madreporite, with several other species belonging to our district, may be found described in the Scarborough Catalogue, a considerable portion of which has been allotted to zoophytes.

Whether any real *alcyonites* occur in our district, may be fairly questioned. Several of the chert nodules in the oolite, formerly mentioned (p. 66, 67), have been allotted to that family. Some of these nodules are pyriform or tuberose, others are shaped like a cucumber. Specimens are found about 10 inches long, and $4\frac{1}{2}$ inches thick. Their cross fracture displays numerous small specks or dots, probably

the sections of minute tubes. As they exhibit no appearance of stars, they cannot be properly termed *madrepores*; but they appear connected with the coral tribes, and ought rather to be considered as *millepores* than *alcyonia*. This remark may apply even to the digitated fossils, which bear a striking resemblance to some recent madrepores as well as recent alcyonia. Some of the chalk fossils called alcyonites, appear to be madrepores, which have had their organization destroyed or altered; others appear to be millepores. To this last family we may assign some chalk fossils, that exhibit a collection of minute, straight, parallel fibres, not unlike petrified wood.

Next to the corals, it will be proper to place that remarkable class of zoophytes distinguished by the names ENCRINITES and PENTACRINITES, or the more familiar term *stone lilies*. These fossils bear a strong resemblance to plants, having stalks from which numerous branches diverge, and many of them having heads like those of lilies. Their stalks and branches are columns of small joints, or *vertebræ*, each of which, when detached, shews on its disk the figure of a star or a flower; a circumstance which serves to connect this family with the madrepores. These detached joints are well known by the name of *St. Cuthbert's beads*.

Animals of this kind are rarely found in a recent state, but their fossil remains occur in great abundance, and in an endless variety of forms. They are arranged into two divisions; the *encrinites*, which have rounded stalks; and the *pentacrinites*, whose stalks or columns are pentagonal. These two divisions are nearly allied, for the head of the encrinite has a pentagonal base, and its joints often display a star with five points, or a flower with five petals. We meet with portions of both in the same specimens; and indeed, had not the *pentacrinus* been discovered recent, we might have supposed, that the whole had originally rounded columns, but that in the pentacrinites the exterior part of the columns had peeled off, leaving the interior pentagonal part displayed.

These two kinds of fossils occur both in our regular strata, and in the alluvial beds; but they are not very plentiful in either. They are chiefly found in the aluminous strata, especially in the lower beds. They are also seen in the dogger, but rarely; and have been observed in the oolite, the upper shale, and the second shale.

In Plate V, we have given a few of the most interesting specimens which have come to our hands. No. 5 is a curious fossil from the alluvial cliffs at Whitby. It shews the head of an encrinite imbedded in a piece of blue limestone. The pentagonal base is very conspicuous; and from it ten branches, or arms, are seen to proceed; one from each side of each of the angular terminations of the pentagon. These arms, instead of folding together to form the head of a lily, are widely expanded. Each of the arms, at the distance of near two inches from the base, divides into lesser arms, branching out in various directions. It is observable, that on the back of this specimen are found some of the starry ends of pentacrinite columns.

No. 4 is a polished section of a specimen of encrinite, contained in a nodule from the alum rock at Saltwick. It displays on the left, a considerable stalk, or vertebral column; and on the right, a curious bulb or turnip shaped figure. These principal figures are surrounded by numerous small branches.

No. 6 is also from the aluminous strata. In the immense number of its branches, or arms, and their manner of spreading, it corresponds with the briaræan pentacrinite, figured in Parkinson's Organic Remains, II, Plates XVII and XVIII: it may therefore be termed *the briaræan encrinite.* One peculiarity in this interesting specimen must not be overlooked;—a number of its branches, or arms, instead of being round, are greatly flattened. This flatness may have resulted from compression, especially as there is a longitudinal crack in most of the flat parts, as may be seen in the upper part of the figure on the left hand. Yet, as the flat parts are intermixed with the round, their

flatness may possibly originate in a difference of organization.—Two belemnites, one large and the other small, are seen imbedded among the portions of the encrinite; and in the other side of the stone is a piece of petrified wood.

No. 1 is part of a pentacrinite of an uncommon size, from the aluminous beds near the north cheek of Robin Hood's Bay. The whole specimen exhibited a number of large branches, with many smaller ones, lying in a confused state, and occupying several square feet on the scar. Many of the branches, or arms, are above a quarter of an inch in diameter, and some of them run nearly in a straight line for about ten inches or a foot; but most of them are bent, and not a few distorted and broken. Though its arms are less crowded than those of No. 6, we may view it as the briaræan pentacrinite, especially as it corresponds with the specimens given by Parkinson, Vol. II, Pl. XVII, Fig. 15 and 16, in having its strongest arms, or vertebral columns, composed of thicker and thinner vertebræ, placed alternately, and forming curiously waved lines at their junction, greatly adding to the external beauty of the columns. Like many of the pentacrinites, it does not display on its vertebræ a star with five points, but a flower with five petals; and the exterior profile of its column is not pentagonal, properly speaking, but presents five rounded projections, something in the way of the clustered pillars in Gothic buildings.

Pentacrinites with sharp angled columns are more common in our strata, but we generally find them in a very broken state. No. 2 exhibits a specimen of pentagonal stars, of the usual form. They occur of various sizes, some of them being very minute. Encrinites are also found, having very slender stalks and branches. An elegant specimen of this kind, imbedded in a small nodule of limestone, is in the valuable collection of Thomas Hinderwell, Esq., at Scarborough. It was found on the beach near that place, among the stones washed down from the alluvial cliffs.

No. 3 is a specimen of a rare fossil, which we hesitate about classing with this family, as the stalks of this sort present no appearance of internal organization, being all in the state of spar. In one of the few specimens which we have met with, and which are all from the Malton oolite, there is a kind of bulb or root, considerably thicker than the stalks, but of no regular shape; and from thence five or six stalks have spread out in various directions, as appears from their mutilated remains. The stalks, which in all the specimens are round like those of encrinites, are plain and smooth towards this root; but at the distance of an inch from it, they begin to assume that beautifully zoned appearance represented in the figure; being girt with belts alternately elevated and depressed, at regular distances, and the elevated zones being each surmounted with a row of tubercles or short spines. In what these singular stalks have terminated, we have not been able to ascertain. We find them running for several inches in the oolite, but have not traced them to any thing like a head, the specimens shewing only detached portions of stalks or columns, partly straight, and partly bent. The thickest of the columns are half an inch in diameter; and all of them are of a brownish colour without, and consist of a dull whitish spar within. This spar splits obliquely, the faces of its crystals being neither parallel to the axis of the column, nor perpendicular to it, but crossing it at an angle of about 45°. This oblique disposition of the crystals, or laminæ, prevails in almost all the sparry petrifactions.

Along with these nondescripts, we may notice another uncommon fossil, delineated in Plate VI, Fig. 11. It is about the size of one of the largest hazel nuts, which it greatly resembles in shape. The upper, or conical part, is not round, but has three angular projections, or ridges, extending from the apex to the base, and nearly equidistant. The base would be almost flat, were it not that these three ridges are continued across it, meeting in an elevated point in

the centre. There is also around the margin of the base, a row of tubercles, or short spines, resembling the tuberculated rings in the fossils last described. Like these, it is from the oolite, the only two which we have heard of, being found together near Kirkby Moorside. It is also brownish without, and sparry within; but it is of a more glassy spar than these fossils, being translucent. Whether it is really a petrified nut, or an animal substance belonging to the zoophyte family, we presume not to determine. It is obviously not an echinite. A splinter having broken off from near the apex, shews some faint appearance of a nucleus, or kernel, in the interior: but we may easily be deceived by the strong resemblance which some zoophytes bear to fruits. The first Figure delineated in Scheuchzer's *Herbarium Diluvianum*, which he calls an ear of corn, appears from its joints and form to be a species of encrinite.

While speaking of uncertain fossils, we may introduce to the notice of our readers a substance, which we have not hitherto seen described, and which, if a petrifaction at all, seems more connected with the zoophytes than with any other tribe. It consists of myriads of parallel fibres resembling hairs, with numerous minute open pores, forming interstices between them. The substance occurs in the oolite, at Malton, Silphoue, and other places, in flat irregular masses, of a brown or blackish colour; varying in thickness, from a line, or little more, to an inch, or an inch and a half; and often extending several inches in length and breadth. Each mass is usually thick towards the middle, and thin at the edges; but we find the mass in some places leaving off abruptly, with a thick edge. The fibres are nearly perpendicular to the plane of the mass; so that, where it is thin they are very short; and where it is thick, they are longer. Where it is bent, they are also bent; and where it forms a kind of arch, they diverge around the arch, like a fan. Some parts of the surface of the mass, in a few specimens, are smooth, in which case

the pores are concealed: but in general we may see the pores on the surface, at least with the help of a glass. Where the surface, or rather any thick edge, has been long exposed to the weather, it displays a singularly cancellated, or reticulated appearance; a multitude of cross markings, which are but faintly seen in the recent fracture, being then conspicuous. This is the case in part of the specimen given in Plate VI, Fig. 12, which is from Silphoue. This fossil is also remarkable, in having been penetrated by the pholas and the teredo. If we consider this substance as a zoophyte, its innumerable pores might well entitle it to be called a *millepore.* The pores, however, are not of a determinate shape, and the hair-like fibres, which may often be detached singly from the mass, vary in their form as well as their size. The substance is calcareous, effervescing strongly with acids. It bears a resemblance to petrified wood; and might have been considered as such, had the fibres been differently disposed.*

The ECHINUS, *sea-urchin,* or *sea-egg,* is so closely allied to the zoophyte family, that it seems proper to introduce here the petrified remains of animals of this genus, known by the name of *echinites.*

The echinus is an animal of a roundish form, covered with a kind of shell or crust, generally thin, which in the recent state is beset with rows of spines, and marked with rows of pores, disposed in avenues. It has a flat base, often somewhat concave, in which the *mouth* is always situated. The *vent* is variously placed; and the whole family is divided into three classes, according to its situation; —the *anocysti,* which have the vent in the vertex, or centre of the upper part; the *catocysti,* which have it in some part of the base; and

* The *screw-stone,* which occurs in the oolite, might have been noticed among the zoophytes. It is evidently the cast of the encrinite column, the body of the column having been dissolved. The *entrochite* limestone, which is found in blocks in the alluvium, owes its peculiar feature to fragments of encrinite columns.

the *pleurocysti*, which have it in the side, or on the upper surface. Some species of all the three classes occur in our district, being found in the chalk, the oolite, the calcareous sandstone, and in nodules of flint in the alluvium; and a few specimens of them are given in Plate VI.

The first class *(anocysti)* comprises two divisions; the *cidaris*, or *turban*, and the *clypeus*, or *buckler*. No. 1, Pl. VI, is a beautiful cidaris from the Malton oolite, corresponding with that figured in Parkinson's Organic Remains, III, Pl. I. Fig. 6, and considered as a variety of *cidaris papillata*. It is marked with five double rows of large *mammillæ*, or tubercles, disposed alternately; each of which is surmounted by a small papilla, having a minute hole or puncture in its centre, and a crenulated ring surrounding it. Around the base of each tubercle, except where it comes in contact with that of the next in the same row, is an elegant circle of minute mammillæ, shaped exactly like the large mammillæ which they inclose, each having its punctured papilla in the centre. The portions of these circles in the interior of each double row come nearly together, and form two lines of minute warts, curiously waved, with a bending suture between the lines. Immediately beyond the exterior portions of the same circles, in the space or area left between the double rows of large tubercles, we find on each side a double row of minute pores, each having usually an elevated margin; which rows run in a bending line, following the curvature of these portions of circles. Each of the five spaces contains two of these double lines of pores, between which is left a small space, adorned with two rows of small mammillæ, placed alternately. Towards the vertex where this space is very narrow, these mammillæ are minute; but near the base they become larger. Between these two rows runs another flexuous suture, like that in the interior of the main rows; and as cross sutures, passing between every two of the large tubercles, join these longitudinal sutures, the whole shell is thus divided into compartments or plates. Some very

minute or granular tubercles often run along the line of the suture. The vent is circular, and has a beautiful pentagonal border. The middle of the base is depressed.

No. 3 is another elegant species of cidaris, which occurs both in the oolite and in the chalk. It appears to be a variety of *cidaris miliaris*, or rather *cidaris diadema;* coinciding nearly with the specimen given in Plot's Oxfordshire, Tab. V. Fig. 5; but more exactly with that in Parkinson's Organic Remains, III. Pl. I. Fig. 4. Its tubercles are of the same form as those of No. 1, and disposed in a similar way; but instead of having five double rows very large and five very small, it presents us with five double rows of moderately large tubercles, and five double rows only a little smaller and closer, alternating with them. Ten double rows of pores pass between these ten areæ, as in No. 1; but they run nearly in straight lines. We also perceive numerous small tubercles, disposed between the larger mammillæ, and sutures dividing the shell into compartments; but with less regularity than in No. 1. This fossil too is considerably flatter than the other, and its base is not quite circular, the five smaller areæ projecting a little beyond the broader areæ. The vent in this specimen is not distinct; but it has no doubt been pentagonal.

Figure 10 is the *cidaris corollaris*, corresponding with that in Parkinson's Organic Remains, III. Pl. I. Fig. 7; which is considered as a siliceous cast. This specimen like that, has a knob of flint above and another below, concealing both the vent and the mouth; the result, as Mr. Parkinson thinks, of an excess of siliceous matter, beyond what was required to fill the shell. The markings of this fossil, which is from the alluvium, are elegant. Like No. 3, it is divided into five larger and five smaller areæ, parted by lines of pores; which lines are only double towards the base, but quadruple on the upper surface. The lesser spaces, which bear but a small proportion to the greater, present two prominent ridges with a furrow

between them. In the perfect state of the shell, it must have been adorned with rows of tubercles, as in Nos. 1 and 3. Vestiges of risings and of waved sutures are still visible.

Of the second division of this class of echinites, the *clypeus sinuatus* occurs in the oolite. It is a flat and broad fossil, some specimens measuring above four inches in breadth. It is figured in Plot's Oxfordshire, Tab. II. Fig. 9, 10; and in Parkinson's Org. Rem. III, Pl. II. Fig. 1. The upper surface is adorned with *ambulacra* or avenues of pores, disposed in the form of a flower with five petals. The margin of each petal, on each side, is somewhat sunk in the shell, and is formed of rows of pores, connected by delicate cross lines. The two avenues, or sides of each petal, which diverge on leaving the vertex, converge near the margin of the shell, and proceed thence in one avenue to the mouth. The rest of the shell, both above and below, is thickly marked with minute circles, each having a small papilla in its centre. Between two of the petals, on one side of the upper surface, there is a deep groove, running from the the vertex to the margin.

This last feature is the principal thing that distinguishes the disk of this echinite from that which we have given in Figure 5. The latter displays also a flower with five petals, the beauty of which is increased by the distinctness of the marginal lines of pores, and the mathematical accuracy of their curvature and intersections. The rest of the surface is occupied with very minute circles and papillæ, as in the *clypeus sinuatus*. Yet, notwithstanding these points of resemblance, this fossil appears to belong to another class of echinites, viz. the *catocysti*, which have the vent beneath. It resembles the *echinanthites orbicularis* of Mr. Parkinson (III. Pl. II. Fig. 2); but is so much more elegant in its form, that we may consider it as a different species, especially as there is no appearance of the two lateral sinuosities observed in Mr. P.'s figure. Our fossil, which is from the calcareous

sandstone of Silphoue moor, is unfortunately incomplete in the margin.

To another division of the same class belongs No. 13, which appears to be *conulus albogalerus;* the same kind of fossil that is figured in Plot's Oxfordshire, Tab. II. Fig. 13, and in Parkinson's Org. Rem. III. Pl. II. Fig. 10, 11. The specimen, which is from the alluvium, is rather defaced; and having something of a projecting ridge at the narrower end, extending from the vertex to the base, it perhaps ought rather to be considered as a *cassis*, or *helmet-stone.* Like most other echinites, it has ten double rows of pores, or *biporous ambulacra*, as they are called; with intervening spaces, alternately broad and narrow. The *conulus albogalerus* occurs in the chalk and the oolite, as well as in the alluvium. In the oolite and the chalk is also found that species of *cassis* called *echinocorys scutatus*, figured in Parkinson's Org. Rem. III. Pl. II. Fig. 4.

Fig. 6 represents a very interesting though imperfect specimen, from the alluvium at Whitby, which is also of the *catocysti* class. It is distinguished by this peculiarity, that instead of avenues of pores, it has avenues of minute short spines. These spines are so disposed as to form a flower with five petals, as in No. 5; and as in that, the petals are depressed; but with this difference, that whereas the middle part of each petal in No. 5 is elevated, and only the margin depressed, the whole of each petal in No. 6 is depressed, and the middle more than the margin. The vertex or centre of the flower is also sunk, and has five spines around it, opposite the five spaces between the petals. The petals, properly so called, do not occupy the whole breadth of the disk, but terminate about half way between the vertex and the margin. Each petal contains two double rows of minute spines, diverging from the edge of the central or vertical hole; and at the termination of the petal, the double rows converge, and become single rows; so that, instead of four rows, only two proceed from

each petal to the margin and the base. The spines are not tapering and sharp, but cylindrical and blunt. They are most slender, and most closely set, in the petals; and are longest in the middle or deepest part of each petal. Each of the spaces between the petals is divided by a waved or zigzag suture, passing from the vertex to the margin, and giving off lateral sutures at each of its angles, in an alternate form. The entire shell has been heart-shaped, having a sinus or depression at its broadest end; and one of the petals points to this sinus. It corresponds nearly with the echinite figured in Plot's Oxfordshire, Tab. III. No. 1 and 2; but the latter is not cordated, but oval, and has its central part not round but oblong. A species of this kind, with raised points instead of pores, is named by Linnæus *echinus pustulosus;* but the reference is erroneously made to Tab. II. Fig. 14 of Plot, a fossil similar in shape, but with avenues of pores. Our specimen is wholly composed of a light grey flint, and the small spines are therefore translucent, and have a whitish appearance. The base is very imperfect, but it appears to have been marked as in Dr. Plot's specimen, Tab. III. Fig. 2.

Of the third class of echinites, the *pleurocysti*, that have their vent in the side, or on the upper surface, some species also occur in our district. No. 2, which is the *cor anguinum* of Linnæus, occurs in the chalk. It is shaped like a heart, and is marked on the upper surface with a flower of five petals, sunk or grooved; each petal having two double rows of pores connected by minute cross lines, the whole converging at the termination of the petal. The largest petal passes into a furrow that forms the depression of the top of the heart, and is the only petal that reaches the margin. It is partly continued on the base, towards the mouth. Directly opposite this petal, and between the two shortest petals, is a keel or elevated ridge, passing from the vertex to the vent, which is at the point of the heart, in the margin. The rest of the surface, between and beyond the petals, is adorned,

as in many other echinites, with minute circles inclosing papillæ. These markings are made too conspicuous and too regular, in Dr. Plot's figure, Tab. II. Fig. 11.

No. 9 of our Plate, is of the same class, but from the alluvium. It bears a considerable resemblance to No. 2; but is of a more oblong form, and has its largest petals towards the point of the heart, and the smallest in the *sulcus*, or furrow, at the top. The two petals next to that, also reach the margin; and the two largest approach to it. The vent in this specimen is very conspicuous.

The last echinite which we would notice particularly, is represented in Figure 4, A and B. Though it is one of the most common in our oolite, at Brompton, Silphoue, Malton, and other places, we have not found it described by any author. It perhaps ought to form a *fourth* class of the echinite family; for its vent is neither in the vertex nor in the base, neither on the side nor near the margin of the upper surface; but is situate at the upper end of a deep sulcus, which runs from the margin to very near the vertex. The vent is, therefore, near the vertex; yet it does not open vertically, but laterally, having its aperture towards the deep groove, and the shell between that and the vertex forming an arch or roof over it; so that it resembles a cave opening into a deep ravine. The shell is nearly cordate, and contrary to what we generally find, the vent is towards the broader end, the deep sulcus forming the depression at the top of the heart.

The upper surface (A) displays a flower with five petals, each of which contains two double rows of pores; and the pores in each double row are connected by delicate cross lines, as in No. 2 and No. 5. The petals do not end abruptly on the disk, but all extend to the margin; from whence, as in No. 5, the pairs of biporous ambulacra are continued along the base, the whole terminating in the mouth; as may be seen in Figure B. The base of the shell, especially

at the mouth, is greatly depressed, and the ambulacra on the base are a little sunk, as they also are in some specimens on the disk. The middle part of each petal is often slightly raised. There is no petal in the deep sulcus where the vent is, but it has one on each side of it, and one directly opposite to it; the remaining two being in the intermediate spaces. The whole surface of the shell, except in the sutures and lines of pores, is marked with very minute circles, each with its papilla in the centre; and as serrated or zigzag sutures pass between the petals, from the vertex to the mouth, sending off alternate lateral sutures; and the latter are also zigzag or waved, and a little raised above the surface,—the whole shell, when viewed with a glass, presents an appearance truly beautiful.

Having examined a number of specimens of this kind of fossil, we have observed several varieties of it. Some have the vent very near to the vertex; in others, it is about half way between the vertex and the margin; some are very flat, others more convex; some have a deep sulcus and are strikingly heart-shaped, others have a slighter depression at the broad end, and approach more to a rounded or oval shape. The latter bear a considerable resemblance to the fossil figured by Parkinson, III. Pl. III. Fig. 8; which he calls *spatangites brissoides ovalis.*

The fossils which are considered as spines of echini, and which may therefore be termed *spinites*, are found in our oolite, in great abundance and variety. They are long cylindrical bodies, resembling the spikes of some species of plantain; having a short stalk, which near its extremity has an elevated band encircling it, and beyond that is presently contracted, ending in another ring slightly raised, in which is a conical hollow, with a deep puncture in the centre; as if the end of this stalk had been fixed on a small cone, with a prominent papilla. The terminal ring is sometimes found crenulated, as if intended to articulate with the larger tubercles of No. 1 or No. 3 of Plate VI.

The stalks of these fossils are mostly smooth, but the bodies themselves are beset with rows of minute knobs, placed in the quincunx form. The rows are often connected by slender threads, running from the stalk to the opposite extremity. This extremity is sometimes blunt and sometimes rather pointed; the bodies being in various shapes, compared to cucumbers, olives, &c.

Fig. 7 (Pl. VI) from Malton, is a good specimen of a spinite. It is thicker than most fossils of this class; but there are others of a more rounded or bulbous form, like olives, of a much greater thickness. Those which occur most frequently are more slender than No. 7, and longer in proportion to their thickness; and their ends are less blunted.

Fig. 8 exhibits a singular group of spinites, from Kirkby Moorside. They have a gentle bend to one side, which seems quite natural, there being no mark of violence, to indicate that they have been forced out of their proper shape. In other respects, they are exactly similar to the common spinites.

These bodies are invariably found in the state of spar, and, as in many other sparry petrifactions, their cross fracture is always oblique, their crystals never cutting their axis at right angles. In many specimens, a central hole is perceived, passing from the stalk to the point, like the pith in trees, as is the case in the vertebral columns of the encrinite. These fossils are found in great quantities mixed with corals, and they might have been classed with zoophytes, had not their connection with the mammillated echinites of the cidaris family been fully established, as may be seen in Parkinson's Organic Remains, Vol. III.

In some specimens of blue limestone, found in the alluvium, we discover small hair-like substances mixed with shells, generally brown and shining, with a lustre like copper. These *acicular spines*, if we may so call them, are some of them in contact with roundish

bodies, nearly in the shape of an *echinus cidaris;* but very differently marked. Each of these bodies displays numerous *striæ*, diverging from the centre to the disk, and passing down the sides; and these lines are crossed, especially on the disk, with several concentric circles. These elevated lines, both longitudinal and transverse, are in several places slightly tuberculated. We have not obtained a complete specimen; but Fig. 14 of Plate VI will give some idea of the appearance of these bodies. They are not entirely round, but have four projections in the sides, presenting the appearance of a square body, with its angles rounded off.*

The ASTERIAS, or star-fish, is nearly allied to the echinus; but we have found no petrified remains of that animal in the district. We therefore proceed to the next and largest class of our petrifactions, viz.

TESTACEA, OR SHELLS.

Were we to describe all the genera and species of shells, discovered in a petrified state in this district, we should give the reader an extensive system of conchology. The limits of our work will only admit a sketch of the most interesting articles in this department.

Shells are divided into three grand classes; MULTIVALVES, consisting of more valves or pieces than two; BIVALVES, or shells having two valves; and UNIVALVES, which consist of only one piece,

* Since the description of the substance figured in Plate VI, No. 12, was printed, we have examined some other specimens of a more decisive character, and have been led to think, that it is a peculiar modification of petrified wood, similar to that described in Parkinson's Org. Rem. V. I. p. 384. Pl. VI. Fig. 11, 16. We may add, that we have recently seen an echinite of the helmet shape, from the Flamborough chalk, corresponding exactly with that in Dr. Plot's Oxfordshire, Tab. II. Fig. 14. It is closely allied to that which we have given in Pl. VI. Fig. 13.

and strictly speaking have no valves at all. The last class is subdivided into UNILOCULAR, having only one chamber or cavity; and MULTILOCULAR, having several chambers.

The multivalve class is very small, containing only the *lepas*, or *barnacle;* and the *chiton;* to which some add the *pholas*, which, besides two principal valves, has small accessory valves upon the hinge and posterior slope. A good specimen of the *lepas tintinnabulum*, a shell that exists in the recent state on the British shores, is figured in the Scarborough Catalogue, Pl. I. Fig. 1. It was found adhering to a fragment of a pectenite, in the calcareous sandstone at Scarborough castle. Having seen few other interesting shells of this genus, and none of the *chiton* or the *pholas*,* in our strata, we pass on to the next class, viz.

BIVALVE SHELLS.

Fossil shells of this class occur in immense numbers, many of them corresponding with those which our seas still produce, but a much greater number that have no recent analogue on our shores; not a few of which have never been discovered, in the living state, in any part of the world. Before attempting any enumeration of genera and species, we would make a few preliminary remarks.

Great difficulty is experienced in arranging our fossil bivalves. There are many that can seldom be obtained in a complete state; and in such as are complete, it is a rare thing to find an opportunity of examining the hinge, from which the discriminating characters of bivalves are principally drawn. Nor is it easy to ascertain, whether a shell has been close, or gaping; and whether its sinuosities,

* The *pholas*, in its recent state, abounds on our shores. For an account of that singular animal, which burrows in the alum rock and the lias beds, see History of Whitby, II. p. 799.

depressions, &c. be natural, or only accidental; as the shells must have been liable to suffer great alterations in their form, when passing from the recent to the petrified state.

The difficulty of distinguishing the genera and species is further increased, by the changes which the very substance of the shells has undergone; their appearance being varied, according as they are found in the state of sandstone, limestone, ironstone, pyrites, agate, chalcedony, or calc spar. Shells in the latter state, which admits of many varieties, are generally much thicker than recent shells of the same kind. It would hence appear that, as water expands in being crystallized into ice, the substance of the shells has expanded in crystallizing into spar.

On these accounts, we rarely meet with fossil shells exactly corresponding with recent specimens; but if we find a general agreement between the one and the other, we may in many cases be satisfied as to their identity. It is a common fault with authors, to multiply the species of fossil shells to an unreasonable degree. Instead of making allowances for the causes of difference now stated, a very trivial variation is with them sufficient to constitute a new species; though we know well, that there are great variations in recent shells confessedly of one species. We may add, that allowance should be made for such variations as depend on difference of climate, as well as for those occasioned by the process of petrifying, the difference of the matrix, or of the substance into which the shells has been converted; for an attentive observer may perceive, that at the era or eras of the formation of our strata, the productions of various climates have been blended together, as is the case with the animals and vegetables of the sea and the land.

We remark further, that though most of the shells be found with the valves adhering, and appear to have been imbedded in the strata while the animal was yet contained between the valves, yet vast

numbers of valves are found single, and many of them water-worn; so that these must have been imbedded a considerable time after the death of the shell-fish, and after many of them had been worn among sand and gravel, like the dead shells which we pick up on the shore. Entire seams of worn shells are sometimes met with, though in general we find both complete and single shells in the same stratum. Some of the strata too abound with minute fragments of shells, with which whole shells are often intermixed.

It is also worthy of remark, that several shells, or parts of shells, are found preserved, not petrified; and this is particularly the case in some of the clay strata, especially in soft marly clay, such as we find in the calcareous beds under the oolite.

These things being premised, we shall now give a list of the principal genera and species of bivalves, belonging to our strata: which we shall do, without arranging them exactly in the order of the Linnæan system.

Solen. *Razor-shell.* Several species of solen occur in the oolite, the calcareous sandstone, and the lowest shale. Among these we may distinguish the *S. siliqua,* the *S. ensis,* and a smaller straight shell resembling the *S. legumen.* A specimen of the S. ensis, or scymetar solen, is represented Pl. VII. Fig. 1. It is from one of the hard seams in the lowest shale, at Robin Hood's Bay; and, though not quite entire, shews the striæ, and even something of the colour, of the recent shell. The oolite abounds most with shells of this genus, especially in the quarries of Pickering and Thornton, where large specimens of the solen siliqua are often met with.

Mytilus. *Muscle.* Of this genus, one of the most singular species is the *mytilus lithophagus,* or stone-eater; which, like the pholas, burrows in rocks, and not unfrequently in corals. It occurs in the oolite, or rather in masses of coral imbedded in the oolite, at Ayton, Malton, and other places. Fig. 5 (Pl. VII) is an interesting

specimen, containing one of the shells with both valves entire, nearly half of another, and portions of two or three more; together with vestiges of cavities, now empty, worn by shell-fish of the same species. The shells are in the state of spar, of a yellowish colour, thin and brittle.

The *M. edulis*, or common muscle, occurs in several parts of the strata. No. 3 is a beautiful pyritous specimen, from a nodule in the alum shale. No. 2 is another handsome muscle, from the calcareous sandstone; differing a little from the common muscle, especially at the beaks, where it resembles the *M. curtus*, or young *M. modiolus*. The latter occurs in the oolite, in its largest size, and with very thick spathose valves. No. 10, which is also from the oolite, appears to be the *M. ungulatus*. No. 4 is the *M. avicula*, or a variety of *M. hirundo*, from the Malton oolite. Small shells, resembling the *M. lingua*, and others in the form of *M. margaritifera*, or *M. unguis*, are found in the oolite, in the ironstone, and in the aluminous strata.

Fig 7 represents a curious cast, from the Kettleness or Staiths bands, or the beds most nearly corresponding with them in the front of Coldmoor. Its general shape approaches to that of the M. modiolus; but, besides the proper beaks, it has on the anterior slope two secondary beaks, or prominent inflections of the *umbones*, which standing up like ears, give that end of the shell an appearance resembling the head of a horse. It seems to be akin to *M. vulgaris*, or *M. plicatus*.

Analogous to this shell is No. 9, which is a cast from the oolite. It has on the anterior slope two large folds of the umbones, which diverging from the hinge again converge, so as nearly to meet, inclosing a kind of cylindrical channel. The base of the shell is rather truncated and keeled. The posterior slope is also keeled; and at the beak end are two large oblong knobs, one on each side of the beaks, which therefore terminate in a kind of gland. On the

anterior slope, at the opposite end of the channel between the folds of the umbones, are two similar knobs, rather larger, forming a considerable swell. In the channel between these two pairs of knobs runs the hinge; which, were there an opportunity to examine it, might perhaps be found to be that of an *arca* rather than a *mytilus;* the shell having some relation to the *arca modiolus.*

Mya. *Gaper.* Various shells that may be assigned to this genus, are found in our strata. Among these we may place No. 6 (Pl. VII), which is from the Malton oolite; or rather, from the grey limestone under the oolite. It seems akin to *M. ovata.* Other oval shells occur at Malton, resembling the *M. pictorum.* The *unio acutus* of Sowerby, Mineral Conchology, Tab. 33, may be noticed under this genus; though its shape rather entitles it to be reckoned a *donax.* It is very common in some of our beds of ferruginous sandstone, particularly in the Kettleness and Staiths bands, as found in the front of the Cleveland hills. A cast corresponding with the *mya mandibula* of Sowerby, Min. Conch. Tab. 43, has been observed in the oolite. In Pl. VIII. Fig. 7, we have given the *unio Listeri* of the same author, Tab. 154. It is from the aluminous strata, where it is pretty common; but it may rather be regarded as a *tellina* or a *donax,* than a *mya* or *unio.*

Donax. *Wedge-shell.* If the shell last mentioned may not be assigned to this genus, it may at least claim that which we have given in Pl. VII. Fig. 8. This shell is from the Staiths band, in which, and in some other parts of the aluminous strata, it is very common. In shape it resembles the D. denticulata, but has the margin entire, and has a depression at the truncated end, immediately beyond the beaks. It is slightly striated longitudinally. In many specimens, one of the valves projects a little beyond the other, at the beaks; and in many, there is a contraction or indentation of the shell in the posterior edge: but as these marks vary in different specimens, being sometimes

striking, sometimes barely perceptible, they can scarcely be viewed as the characters of a distinct species. The specimen figured, which is from the front of Coldmoor, retains something of its original purple colour.

Fig 11 (Pl. VII) represents a shell of a similar form from the oolite. The depression at the truncated end is rather deeper than in No. 8, and the other end is broader and more rounded. Besides, the shell is not only striated, but antiquated; a character which is seen very faintly, if at all, in No. 8, and other specimens of this donax from the aluminous strata. This fossil is sometimes met with of a considerable size, measuring above three inches in its greatest diameter.

We are at a loss to decide, under what genus the shell figured in Pl. VII. No. 12, should be placed; but it seems to be related to the donax family. Mr. Parkinson, who is equally at a loss to class it, has figured it in his Organic Remains, III. Pl. XIII. Fig. 16. Our specimen, like his, is a cast; but is much more perfect and beautiful. We have other specimens with the shell, but less perfect. The shell is marked with the same kind of straight ribs, passing across each valve in a peculiar form; those from the anterior slope being nearly at right angles with the line of that slope, and those from the posterior slope leaving it also at right angles; so that, as the two slopes make an obtuse angle at the beak, the two sets of ribs on each valve, those at least that are not remote from the beak, converge in the middle of the valve, in a line passing from the beak to the base. Towards the beaks, there are a few slight cross markings, between the two sets of ribs. In the shell, at least in the larger and (we may presume) older specimens, the ribs do not reach the margin; but each valve has a plain border, beyond the ribbed part, marked only with concentric striæ. A few concentric or transverse lines also cross the ribbed part of the shell. This curious fossil shell occurs

chiefly in the oolite; but it is also found in the ironstone beds, and in the dogger that covers the alum rock. Our largest specimen measures two and a half inches in the one direction, and near one and a half in the other. In its general shape it is very like No. 6 of Pl. VII.

Here also we may introduce the shell figured in Pl. IX. Fig. 15. It is from the lowest shale, or the hard seams in that shale; and is chiefly found in Robin Hood's Bay. It is shaped nearly like No. 8 of Pl. VII; but is much more gibbous, has more prominent beaks, and has a deep depression at the place of the cartilage, besides that at the truncated end; whereas the corresponding depression in the other shell is generally slight. It has several strong ribs passing from the beaks towards the base, and these are more or less crossed by transverse concentric ridges, especially near the base, or rounded margin. The transverse lines are most prominent in the older shells; and in these, as was remarked of No. 12, Pl. VII, the ribs do not reach the base, but there is a margin marked only with the concentric lines. The truncated end is more slightly marked than the rest of the shell. Each of the slopes, viewed in front, has the appearance of a heart-shaped leaf. The number of the ribs varies considerably; and they are most numerous in the younger shells. Some shells, similar in size and form, apparently without ribs, occur in the same place; but of these we have not procured any good specimen.

Plagiostoma. *Wry-mouth.* Under a genus of this name, Mr. Sowerby has classed a pretty numerous family of shells, which Mr. Parkinson, with some hesitation, placed under the genus donax. This kind of shell, like the donax, has the area straight, flat, and lengthened; and the base rounded. Its grand discriminating character is, that it has small ears, one on each side of the beaks, forming a line that crosses the beaks obliquely; and has in the one valve a triangular cleft or opening, at the beak, while the other valve is entire, or nearly entire. This cleft is principally in the right valve.

Mr Sowerby has enumerated *eight* species of plagiostoma; but they may perhaps be all reduced to *two* or *three*. If every little difference in the shape or the marking of shells be admitted as the foundation of a new species, we shall find one in almost every new specimen.

Fig. 3 of Pl. VIII is a most beautiful specimen of Mr. Sowerby's *plagiostoma rigida*, from the oolite near Malton. One of the ears is broken off, and indeed few specimens have both perfect. The shell is handsomely marked with slender longitudinal ribs, somewhat zigzag, or waved; and these are crossed in various places with concentric markings, or rings of growth, especially toward the base, where these circular lines usually form a rich border, as is the case in this specimen. As the original brownish or purplish colour of the shell partly remains, and as the concentric lines are here of a lighter colour, the beauty of the border is the more striking; and even the zigzag disposal of the ribs contributes to enhance it.

It is observable, that though this is a *left* valve, it has the triangular cleft at the beak very conspicuous, and Mr. Sowerby's figure seems to have the cleft in the same valve.* In most specimens which we have examined, the right valve displays the cleft; or rather, we may say, the principal cleft; for both valves contribute to form the aperture at the beaks. The differences on this head do not appear to constitute different species. The same remark applies to the size of the shells, and still more to the concentric rings that traverse the ribs, as these are scarcely alike in any two specimens. We may even extend this observation, in some measure, to the general shape of the shell. Some specimens, like the one figured, resemble a cockle or a pecten; some have the oblong and wedge-like shape of a donax;

* Mineral Conchology, Tab. 113. Fig. 1. By some oversight, Tab. 113 in the engravings, here referred to, corresponds with Tab. CXIV in the printed description; and Tab. 114 corresponds with Tab. CXIII.

some are flat and broad in the form of the letter D; and some approach the shape of the trigonia; yet, as some of all these forms are marked with the same waved or zigzag ribs, crossed by the same kind of zones, we can scarcely consider them as any thing more than different varieties of the same species. By adopting an opposite course, we might multiply species *ad infinitum;* so many shades of difference being discernible. Sowerby's *plagiostoma ovalis, p. cardiiformis, p. obscura,* and even *p. pectinoides,* may all be varieties of *p. rigida.* Nay, we may perhaps add *p. punctata,* and *p. gigantea.* The former differs from *p. rigida,* chiefly in being striated more finely, and marked with fainter circles; which may be accounted for by a difference of the matrix, as well as some accidental variation in the shell. In one of our specimens, of the donax shape, part of the shell is nearly or entirely smooth; part is striated with rows of points, as in the *p. punctata;* and part of it is marked with the deep waved lines of *p. rigida;* according as the shell has been more or less exposed, the difference having apparently been produced by friction.

P. gigantea seems to have no better claim to rank as a distinct species. We have a deltoid specimen from the grey limestone, about four inches in diameter, corresponding with Mr. Sowerby's specimen. Its surface is mostly smooth, or marked with faint striæ; but the faintness of its markings may be viewed as the result of age, or of the decomposition or removal of the outer part of the shell; for in the front, where it has been least exposed, we find some strongly marked ribs, somewhat waved.

P. spinosa of Sowerby, must be regarded as a distinct species; not only on account of its spines, which are sometimes wanting, but also on account of the coarseness of its ribs or furrows. Among our specimens is one very coarsely ribbed, from the oolite, as large as that last mentioned, but with scarcely any vestiges of spines. It is more of a deltoid shape than Mr. Sowerby's specimen, and the absence

of the spines, of which it bears but equivocal traces, makes us doubt whether it can be reckoned of this species or not. It may, however, be a variety of it.

As the *waved* ribs or striæ appear to form a characteristic mark of the species first mentioned, it may be proper to name it *undata*, rather than *rigida;* as the latter character does not appear essential. It appears to be further distinguished by a complicated tooth-like process at the end of the anterior ear, on that valve which is the least cleft. This process being usually dressed away, by those who discover or clear out the specimens, we have met with it only in two or three instances. It is formed by a raised fold of part of the ear, and a piece projecting from the end of that fold; but we are not sure that we have seen it in a complete state. Mr. Parkinson found it in only one specimen, and considered it as a lateral tooth: Mr. Sowerby does not appear to have seen it at all; his observations being chiefly made on *p. spinosa*, in which it is not found. In one of our smoother specimens, this process, or something similar to it, appears at the very beaks. Perhaps on a more full examination of the shells of this singular genus, the form or disposal of this process may be found to constitute an important specific character.*

We may only add, that all the specimens of plagiostoma which we have seen are from the oolite, or the grey limestone under it. They are principally obtained from the neighbourhood of Malton, particularly from Swinton. Several of them are much compressed.

Trigonia. This new genus of Bruguiere, which has been discovered recent in some parts of the world, may be introduced here,

* See the figures referred to in this article, in Sowerby's Min. Conch. Tab. 77, 78, 113, 114. Parkinson's Org. Rem. III. Pl. XIII. Fig. 6. Sowerby (p. 175) quotes the latter erroneously as Fig. 3. The Scarborough Catalogue gives a good specimen in Pl. I. Fig. 3; but in the printed description, p. 107, the reference is made by mistake to Plate II. Fig. 1; which last is an indifferent specimen of the fossil which we have given in Pl. VII. Fig. 12.

as being somewhat akin to the *plagiostoma;* as it also is to the *venus,* the *arca,* the *mytilus,* the *cardium,* and the *tellina.* Some species of trigonia have been found in our strata; chiefly in the oolite, and the calcareous sandstone, but partly also in the dogger over the alum rock.

Fig. 18, Pl. VIII, is a specimen of the *trigonia clavellata,* from the oolite at Pickering; where this kind of shell is principally found. It is handsomely studded with tubercles, disposed in rows; and exactly agrees with Parkinson's figure, III. Pl. XII. Fig. 3; and with Sowerby's, Tab. 87.

Fig. 18 *a* is the curious hinge of this species, as it appears in the right valve. It greatly resembles the hinge of the recent shell, the *trigonia margaritacea,* represented in Parkinson's Org. Rem. III. Pl. XII. Fig. 2. We have not succeeded in clearing out the hinge of a left valve; but no doubt it would correspond with Fig. 1 of Parkinson's Plate.* Two muscular impressions are found near the hinge; but the smaller one is so close to a part of the hinge, that it is apt to be confounded with it, or overlooked, especially in the right valve: yet in some of our specimens, particularly in a left valve, the smaller impression is very distinct.

Fig. 19 is a beak of the *trigonia costata,* also from the oolite. It is less common than the *t. clavellata.* The umbones in this shell are adorned with smooth ribs, instead of rows of knobs. The *t. aliformis* and one or two additional species are said to have been found in alluvial nodules; but we have not had an opportunity of examining them.

A beautiful trigonia occurs in our dogger, at Falling Foss and some other places, differing from any which we have hitherto

* Either that author has by mistake interchanged the words *right* and *left,* or has adopted a different definition of these terms, as applied to valves, from that of Burrow, in his Elements of Conchology, p. 33. 2nd. Edit. Hence our *right* valve corresponds with Mr. Parkinson's *left* valve, and vice versa.

seen described. It greatly resembles t. clavellata; but instead of rows of knobs, it is adorned with ribs; and these are not smooth, as in t. costata, but each of them is surmounted by a row of very minute tubercles. In the area, or front, the shell bears so strong a resemblance to t. clavellata, that it may possibly be no more than a variety of that species, perhaps in a younger state; these shells in the dogger being smaller than those of t. clavellata in the oolite. Fig. 20 is the beak of one of these shells.

Cardium. *Cockle.* Many cockle-shaped shells occur in our strata; but only a small number of species have been ascertained to belong to this genus.

C. edule, or the common cockle, is said to have been found in the Malton quarries; but it has not come under our notice. Fig. 4, Pl. VIII, is a beautiful cockle, from the grey limestone in that quarter, resembling *c. lævigatum;* but it is of a rounder and more handsome shape than any shells of that species which we have seen; and is rather more elegantly marked. The number of the ribs is fifty, or upwards. Sowerby's *c. semigranulatum,* Tab. 144, is akin to it.

C. pectinatum, called also *æolicum,* or one greatly resembling it, is the most abundant species in our strata. It is striated longitudinally in the front, but transversely on the disks; as may be seen in the specimen, Fig. 5, Pl. VIII. It is found in great abundance in the bands that run in the alum shale; both the ironstone and sandstone bands. Peak, Boulby, and the fronts of the hills near Stokesley, are the places where it is most common. Yet, though it is so plentiful, we rarely meet with a specimen in which the shell is complete: for the shell is usually gone, and only the heart-shaped cast left; or the latter comes out entire, while the former is broken to pieces, or left in the matrix. The best specimens are obtained from the ironstone. There is much variety in their size; some being only half an inch long, while others are an inch and a half, or upwards. The average

dimensions are,—about an inch long, an inch and a quarter broad, and three quarters of an inch thick.*

The shell figured by Parkinson, III. Pl. XIII. Fig. 3, and named by Sowerby (Tab. 14) *c. hillanum*, is not the same with our cockle. The principal striæ in the front of our shell are elegantly bent, meeting in the line of the hinge; and these curved striæ are crossed, in the parts furthest from the beaks, by a few straight striæ, rather faint, diverging from the hinge line. The curved striæ not only cover the area, but encroach a little on the disks, on each side. The beaks are incurved, so as nearly to meet.

Small shells resembling the *c. ciliatum*, are not uncommon in the lias seams and nodules, in the oolite, and the calcareous sandstone. Fig. 16, Pl. VIII, represents a specimen from the oolite, which in the number and minuteness of its ribs, or longitudinal striæ, resembles *c. serratum*. Nodules containing large collections of shells of this kind, some of them very minute, are frequently met with in the alum shale near Whitby. Not having seen the hinge, we have doubts whether these shells belong to this genus. Fig. 1 is another small shell, from the ironstone, resembling Fig. 16 in the number and minuteness of its striæ; but it is more ventricose, and has a more depressed area.

TELLINA. Of this shell a few species only can be particularized. Fig 2, Pl. VIII, corresponds with the *t. crassa*. It is from the Malton oolite. It differs little from the *t. obtusa* of Sowerby, Tab. 179, Fig. 4. A shell like *t. fragilis* occurs in the ironstone beds, and others that may be ranked under this genus are found in the oolite.

* It may be necessary to apprise some readers, that the *length* of a shell is the distance from the beaks, or the region of the hinge, to the opposite margin; and the *breadth* is a line at right angles to that direction. In some shells, particularly those of the solen family, the breadth is vastly greater than the length.

The deeply sulcated shell, Fig. 17, imbedded in a piece of dogger, may be noticed here; though it is so much entangled in its matrix, that we cannot decide, whether it is a tellen, a venus, a mya, or a shell of some other genus.

Venus. Under this genus we have also but little to introduce. Fig. 6, Pl. VIII, is a handsome cast of a venus from the dogger. It resembles the *v. rugosa.* A beautiful flat lenticular shell resembling *v. edentula,* occurs in the nodules in the dogger beyond Peak, at the place where the alum shale first rises to day. The inside of it has a rich shining surface, somewhat nacrous.

Anomia. This genus is one of the most abundant in our district, occurring in the chalk, the oolite, the various kinds of shale, the calcareous sandstone, and the ironstone. The shells are chiefly distinguished by a hole in the point of the upper or larger valve; at least most of the species found here have the beak perforated.

Fig. 13, Pl. VIII, is from the chalk. It is the *terebratula semiglobosa* of Sowerby, Tab. 15, Fig. 9; being a small shell, nearly globular, distinguished by the remarkable waved line, marking the junction of the two valves. The middle of each valve is smooth.

Fig. 9 is also from the chalk. It corresponds very nearly with *terebratula intermedia* of Sowerby, Tab. 15, Fig. 8. It has in some places a slight tinge of red or brown. Fig. 12 agrees with Sowerby's *t. tretraedra,* Tab. 83, Fig. 4; which seems to be the same species with his *t. media,* Fig. 5. It abounds in the sandstone and ironstone bands, belonging to the aluminous strata; where also Sowerby's *t. lateralis,* or *t. crumena* (for they seem to be varieties of one species) may often be met with.

No. 11 is a smaller shell, not unlike No. 12, but much more flat; and instead of a sudden rise of part of its plaits or ribs, it is distinguished by a gentle undulation of the whole; the plaits, which are numerous and small, proceeding round the base, in an unbroken

series, and forming a handsome bending line. Its margin is sharper than that of any other species, owing to the flatness of the shell; on which account, as it does not appear to have been hitherto described, we would name it *anomia compressa.* It is from the oolite; in which, and in the grey limestone, this species and No. 12 are not uncommon.

Fig. 10 represents a large anomia from the second shale. It abounds in the cliffs near Gristhorp; but is seldom found entire, being generally mutilated at the base. It appears to be the *terebratula ovoides* of Sowerby, Tab. 100; of which his *t. lata* is only a variety. In the form of the beaks, the gibbous and oblong shape of the shell, the disposition of the striæ in the valves, and the absence of undulations at their junction, this shell also coincides with *t. digona* of Sowerby, Tab. 96; which may possibly be another variety of this species, being often found without the angular projections. As our specimens are almost all either mutilated or compressed at the base, indicating a weakness of structure in that part of the shell, some of them may have had angular projections. The shell is of an olive colour, and has often a smooth and shining aspect, the striæ, which are all transverse, being very fine. This species likewise resembles *t. biplicata* of Sowerby, Tab. 90; but has not the folds of that shell.

No. 14 is very common in the nodules and bands of the aluminous strata, both in the sandstone and ironstone. It corresponds in shape with the *t. subundata* of Sowerby, Tab. 15, Fig. 7; being broad and flat, with the margin very faintly undulated. Our shell is somewhat striated in both valves, longitudinally as well as transversely. It is often of a considerable size, some specimens being about two inches long, and an inch and a half broad. Sowerby's *t. ornithocephala,* Tab. 101, is nearly allied to this species, if not the very same.

No. 8, which is from the chalk, differs from any species which we have seen described. It is a smooth shell, nearly as long as No. 14, but narrower, and more gibbous. Its chief discriminating character is the marginal line, which, except a slight depression near the beaks, is straight till it reaches the middle of the shell, when it bends upwards into a considerable arch, that reaches to the base. The line of the base, connecting the arch on the one side with that on the other, is nearly straight, and occupies a space equal to half the breadth of the shell. If this shell is not a variety of *t. subundata* of Sowerby, we might name it *anomia arcuata.*

The *anomia ephippium* is often found in our strata, adhering to fossil oysters. We may here add, that on a closer examination of the singular shell, figured in Pl. VI. No. 14, it is found to correspond with the *a. producta* of Martin, delineated in Parkinson's Org. Rem. III. Pl. XIII. Fig. 9, 10. Sowerby makes this shell a new genus, which he names PRODUCTUS; and it may be noticed, that as we discovered hair-like substances connected with our specimens, several of those which he has figured, Tab. 68, 69, display minute spines.

MACTRA. Shells resembling the *m. stultorum* occur in the aluminous strata; and large shells like the *m. lutraria,* are found both in the oolite, and in the ironstone bands.

SPONDYLUS. A species approaching to the *s. radula* of Lamarck, of considerable size, is noticed in the Scarborough Catalogue (p. 108, 109), as occurring in the Malton oolite, and in the ironstone beds near Scarborough. We have not had an opportunity of examining it.

CHAMA. The beautiful little shell, Fig. 5. Pl. IX, has a strong resemblance to the *chama calcarata* of Lamarck, figured by Parkinson, III. Pl. XIV. Fig. 13; and if not the same species, must be near akin to it. It is from the ironstone, and retains something of its original colour and pearly lustre. It is marked with concentric transverse plaits or rings; and the intermediate spaces are adorned

with rows of oblong knobs, which appear to have terminated in minute spines, now broken off.

In the oolite at Old Malton, we found a fragment of a large shell of this genus, with very deep ribs covered with scales; but whether it belongs to the *c. gigas*, or to some other species, we cannot decide.

As the handsome pyritous shell, Fig. 15, Pl. VIII, approaches the shape of *c. calcarata*, we may notice it here, though it very probably may belong to another genus. It is imbedded in a pyritous nodule from the alum shale, and is only imperfectly seen. It is finely striated or ribbed, with transverse concentric lines.

Arca. *Ark.* Of this kind of shell, only a few species are known to exist in our strata. The most common is that figured in Pl. VIII. No. 21, which abounds in some parts of the alum shale, especially near Whitby east pier. Mr. Parkinson placed it under the genus *tellina*, with some hesitation, Org. Rem. III. p. 192. Pl. XIII, Fig. 4; but the hinge which we have figured, No. 21 *a*, shews it to be an *arca;* and to belong to that division in which the teeth are in a broken line. It corresponds so exactly with the recent British shell, the *arca rostrata*, both in its shape, its size, and its striæ, that there can be little doubt of their identity. There are two muscular impressions in each valve, one at each end of the hinge; in which respect, as well as in its external form, it appears to coincide with the recent shell. The fossil shell being in a state of spar, is thicker, as may be expected, than the recent shell usually is; but it has evidently been a weak shell, great numbers of the specimens being much bruised or compressed. It often retains something of the original horny colour, but in some of the hard nodules it has a bluish tinge.

No. 22 is the right valve of a large ark, from the oolite, which does not agree with any species that we have seen described. Its shape is somewhat ovate and gibbous; and, like the *arca noæ*, it has

incurved remote beaks, with a broad flat space intervening; which space or area is elegantly marked with four sets of straight lines, parallel to the edges of the area, meeting in the hinge line at one end, and in a line passing from beak to beak at the other. The shell is marked with transverse lines; but the markings in our specimens are somewhat defaced.

In some of our ironstone beds, we find a shell greatly resembling the *arca glycymeris;* but we have not discovered the hinge.

Pecten. *Scallop.* Few shells are more abundant in our strata than this; the oolite, the ironstone, and the calcareous sandstone being replenished with a great variety of species. These species it is not very easy to distinguish and describe; as they generally occur in single valves, with the ears more or less mutilated. Some of our most beautiful and singular scallops are delineated in Plate IX.

Fig. 8 represents the inside of a valve, belonging to a species that is either the *pecten subrufus* (or *opercularis*), or one nearly allied to it. It is from the Staiths beds, and measures two inches each way. Very large specimens, of the same form, measuring four or five inches, occur in the sandstone and ironstone bands in the aluminous strata. They have been supposed to belong to *p. maximus* or *p. jacobæus;* but they differ considerably from both these species, having both valves convex, though not equally so. Of these shells we may distinguish two species; one with decussated striæ, or striæ both longitudinal and transverse, which we may consider as the *p. subrufus;* and another having remarkably rounded ribs with flat intervals, marked only with fine transverse striæ. The latter species agrees with the *p. equivalvis* of Sowerby, Tab. 136; only the ribs in our shells, instead of being narrower than the intermediate spaces, are usually much broader. The number of ribs, both in this species and in the *p. subrufus,* varies from eighteen to twenty-two, twenty being the average.

No. 9 agrees with the *p. varius*, having unequal ears, and between twenty and thirty spinous imbricated ribs. The ribs vary in number, especially as we often see two ribs coalescing into one, or one dividing into two; as may be observed also in the very correct figure of the recent shell in Pennant's Zoology, IV. Pl. LXI. This shell, which measures two inches or more in length, and somewhat less in breadth, is found in the oolite near Malton. In the same place, we meet with a shell greatly resembling it in form and size, but with only about eighteen ribs, and these not spinous, but transversely wrinkled, and sometimes rather scaly. It appears to be *p. citrinus*, or a variety of *p. senatorius*. In the oolite we also find a pecten, sometimes three inches long or upwards, having ten large ribs, with imbricated transverse striæ. The ribs appear to have been somewhat prickly, and the shell is perhaps allied to *p. sanguinolentus* (or *ostrea sanguinolenta*); but our specimens of it are all imperfect.

No. 3 is a perfect valve of a beautiful little pecten, very common in the oolite, and in the calcareous sandstone under it. We may term it *p. sulcatus*, as it corresponds very nearly with Dillwyn's *ostrea sulcata*; having eleven or twelve prominent ribs, traversed by sharp scales, or oblong spines. The grooves between the ribs are faintly marked with transverse striæ, connecting the scales that cross the ribs. Only a few longitudinal striæ are discernible, so that the shell differs a little from *o. sulcata*.

No. 12 is about the same size as No. 3, each of them being nearly an inch long. They have also the same number of ribs; but those of No 12, which is a wider shell, are rather broader and flatter; and instead of sharp scales, are traversed by slender undulating membranaceous striæ, which cross the grooves as well as the ribs, and are so closely set as nearly to cover the whole shell. This seems to be the *p. fibrosus* of Sowerby, Tab. 136. Fig. 2; and it is probably allied to the *ostrea striatula* of Linnæus, which has sixteen

ribs, with transverse membranaceous striæ. It belongs to the oolite, and the grey limestone. A shell resembling this and No. 3, but with sixteen smooth ribs, occurs in the ironstone.

Fig. 10 represents the inside of a handsome shell, of a larger size, and more oblong shape, from the hard sandstone at the foot of Scarborough castle. Some specimens are three inches long, but it is very difficult to get any entire. Both valves are convex, and, as in No. 12, are closely invested with transverse membranaceous striæ, somewhat sharp and rough, crossing both the ribs and the intermediate grooves. There are nine ribs, which are broad and rather flat, but each has an elevated ridge running along the middle of it, surmounted here and there with oblong spines, or sharp scales, crossing the ridge. As this species does not appear to have been hitherto described, we may name it *p. Scarburgensis.*

No. 11 agrees pretty well with *p. pusio;* but one of the ears in our fossil has no distinct line of separation between it and the valve. The specimens, which are all from the oolite, differ considerably; their numerous filiform ribs being more or less crossed by transverse scaly wrinkles. In some, the ribs are minutely echinated, and alternately smaller; and as the number of the ribs is seemingly doubled where this alternation takes place, such specimens are allied to *p. islandicus* or *cinnabarinus.*

No. 1 is a beautiful shell from the Malton oolite, which we have not seen described by any author. It is nearly circular, and is commonly about two inches in diameter. The ears resemble those of No. 9; and the valves, instead of being ribbed, are adorned with innumerable longitudinal striæ, finely waved, scarcely visible at the beaks, but growing more and more distinct towards the margin. These striæ are crossed by a few concentric rings, which mark the shell in the antiquated style, the margin growing lower and lower beyond each successive ring. These rings have no determinate

number or position; but there are generally two or three, the shell appearing as if it consisted of three or four thin valves, of different sizes, adhering to one another. This fossil and No. 11 have generally a reddish or brownish hue. They are both flat and thin shells. In honour of Malton, where so many interesting fossils are obtained, we may name this shell *p. Maltonensis.**

No 6, from the ironstone bands of the aluminous strata, is perhaps another nondescript. It is the cast of a shell resembling *p. Danicus* (or *ostrea triradiata*), having very unequal ears, the valves marked with very minute longitudinal striæ, and with four or five ribs or elevated plaits; the ends of which project at the margin, the intervening marginal spaces being either straight or slightly bent inwards; giving the shell the appearance of the webbed foot of an aquatic fowl. Some of our specimens are three inches in diameter, which is double the size assigned to *p. Danicus*. Should our shell prove a new species, we would name it *p. cygnipes*.

No. 4, from the same strata, is perhaps the flat valve of a smaller shell of this species, having markings somewhat similar; but it has no angular points in the margin; the plaits, though corresponding in number, are not elevated but sunk; and instead of proceeding to the margin, disappear at about two thirds of the length from the beak. This valve is rather concave in the middle; and is marked, near the margin, with two or three transverse rings, or lines of growth. If this shell belong to the same species as No. 6, it cannot be the p. Danicus; but it is not unlikely to be another species.

Nos. 2 and 7 are of that class of pectens which have a crooked appearance, leaning or bending to one side. No. 2 is very abundant in the ironstone and sandstone beds of the aluminous strata. It is a smooth shell, marked with about ten slender ribs, handsomely bent;

* Specimens of most of the Malton fossils may be procured from Mr. John Larkum of that place, an indefatigable collector.

and seldom exceeds an inch in diameter. The ears are of a moderate size, nearly equal. As it abounds about Rosebury Topping, we may name it *p. Roseburiensis.* A similar shell from the same strata, inferior in size, but with about fourteen ribs, approaches the common shape of a plagiostoma, and may therefore be called *p. plagiostomus.*

No. 7, similar in shape, is from the oolite. It has seven or eight ribs, of which those in the middle are vastly larger than those on either side. If it is not the *p. flavicans,* we might name it *p. inequicostatus.*

Ostrea. *Oyster.* This is another shell abundant in our strata; and were we, with Linnæus, to include the scallops under this genus, the family would be numerous in the extreme. The fossil oysters occur in more of our beds than the pectens; for we find them in the ironstone and sandstone bands of the alum shale, in the alum shale itself, in the dogger, in the blue limestone, in the calcareous sandstone and ironstone of Scarborough and Filey, in the upper and second shale, in the oolite, and in the chalk.

The *o. edulis,* or common oyster, is found in all its varieties; large, and small; rough, and smooth; round, and irregular; water-worn, and entire; in single valves, and in double. The Staiths beds include large seams consisting almost entirely of oysters, of various kinds, and in various states. Some of the shells are of a handsome circular form, others of a deltoid shape; some are large and thick, others small and thin. Very large oysters, from six to nine inches or upwards in length, are occasionally met with in the higher ironstone beds, near Scarborough and Filey; as also in the oolite, and in the upper shale. Several of the shells alluded to may be distinct species, rather than varieties of *o. edulis.* At any rate, we find several other species of this genus, a few of which will require to be noticed.

Fig. 14, Pl. IX, represents a handsome plaited oyster, occurring in the calcareo-ferruginous sandstone of Filey, and of Scarborough.

The specimen is from Filey Bridge. This is the *o. diluviana* of Linnæus, figured by Parkinson, III. Pl. XV. Fig. 1; and by Sowerby, Tab. 48, under the name *o. Marshii.* The recent *o. Sinensis* is probably of the same species, which admits of many varieties. Fig. 1, Pl. X, displays the plaited edge of an oyster of this family, from the upper shale. The great thickness of its edge, with some differences in its shape, might entitle it to be regarded as a distinct species from that last mentioned, had we not intermediate specimens to connect them. It would seem, that in the younger shells, such as No. 14, Pl. IX, the plaits are few, and only two or three of the laminæ that compose them reach the margin, while a succession of other laminæ may be seen proceeding towards it, at different distances; whereas in the old shells, such as No. 1, Pl. X, the plaits are very numerous, and their laminæ have all, or almost all, arrived at the margin, where they form a solid zigzag border. In the former, we find a protuberance, more or less broad, in the region from whence the plaits diverge; in the latter, this protuberance covers most of the disk, appearing like another valve adhering to the back of the shell. Further, the young specimen is somewhat oblong oval, measuring about three inches long, and above two broad; but the old specimen is of a deltoid shape, having a projecting lobe on one side of the base, and measures above four inches long, and nearly four in breadth, from the point of the lobe to the opposite side. The growth of lobes often forms the difference between old and young univalves, and the same curious fact seems to occur here. The hinge of this shell is striated across.

Fig. 2, Pl. X, is a singular oyster from the Speeton or upper shale, resembling the hoof of an ox, and having a narrow incurved beak. The shell is smooth without, or marked slightly with lines of growth. It has a deep oblong cavity within, extending from the beak to the base. The one side of this cavity is the flat part or base

of the hoof; the other is a thick ridge running along the inside of the curved part of the hoof. Above this thick ridge rises a thin lobe or margin, which seems to have been continued round the base of the shell, but is always found imperfect. We have not seen a specimen with the smaller valve, or cover. From its remarkable shape, we may call this shell *o. unguis*. Its curved beak resembles that of a *gryphæa*.

In the same shale, we find a large, massive, and very deep oyster, of a deltoid or subtriangular shape; with a very rough knotty exterior, but smooth within. Its beak is incurved, like that of *o. unguis;* but it is rough and irregular in its appearance, with transverse coarse markings, which are more or less continued on the disk, and which are so distorted, that they can scarcely be called either striæ or folds. The inside displays a large and deep subtriangular cavity. The cover, or lesser valve, is of course subtriangular; and it is concave, having a considerable hollow in the middle. Both valves are very thick; and in both, especially in the smaller valve, the large muscular impression is deeply marked. Beside it, in the larger valve of our best specimen, is a knob containing a pearl. This specimen is five inches long, four broad, and nearly three in depth. It weighs twenty-six ounces. This oyster, like *o. unguis*, appears to be a nondescript; and, from its large cavity, we may term it *o. capax*.

Fig. 16, Pl. IX, is the *o. gregaria* of Sowerby, Tab. 111; called by some *o. frons*, and not unlike the *o. pectinata* of Lamarck. It is found in the oolite, and in the calcareo-ferruginous sandstone. The shell is finely plaited, and the margin displays zigzag markings, as in o. diluviana. It has often a bend near the beaks; where also we sometimes find a lobe, or excrescence, on one side. The shells of this family are often found in clusters, adhering together. A thin parasitical shell, with obtuse plaits in the margin, like the *o. folium*, occurs also in the calcareous sandstone. It is not uncommon to find even large oysters adhering together, particularly in the upper shale.

Fig. 13, Pl. IX, represents a small shell from the oolite, of an oblong form, and singularly marked; being striated longitudinally towards the base, but transversely near the beaks. It is difficult to say, whether it is an ostrea, or a chama, or neither. This remark applies also to a very large shell, found in the Flamborough chalk; very similar in shape, and marked with coarse transverse furrows, that are deepest near the beaks. This is the largest of our oysters, if we may include it in the family. One of our specimens has measured, when entire, about a foot in length, and seven inches in breadth.

No. 3, Pl. X, is a shell from the oolite, which also we hesitate to place in this family. It has the ruggedness of an oyster, with the ribs of a pecten; which last it agrees with in shape, but we have not discovered any ears. The margin, like the surface, is very irregularly waved. Some specimens exceed four inches in diameter.

There are many ostracites, in the bands of the aluminous strata, having one valve remarkably gibbous. They seem to be of two different species; one being very small, roundish, and wrinkled; the other oblong, nearly smooth, and two or three inches long. The latter resembles the shells of the next genus.

GRYPHÆA. *Boat-oyster*, or *miller's thumb*. Gryphites are found in our strata in considerable quantity; particularly in the lowest shale, as in Robin Hood's Bay, at Boulby, and at Redcar rocks; and in the calcareous sandstone, as at Scarborough, Filey, and Rowlston scar. Like the ostracites, they are seldom sparry, but retain the appearance of recent shells. Fig. 23, Pl. VIII, represents the most common species; corresponding with that of Parkinson, III. Pl. XV. Fig. 3; which Sowerby, Tab. 112, names *g. incurva*. It occurs in various states; small, and large; smooth or slightly striated, and strongly wrinkled. Numbers are often found clustering together.

Fig. 4, Pl. X, is Sowerby's *g. dilatata*, Tab. 149. It occurs in the hard sandstone at the foot of Scarborough castle, in Rowlston

scar, and a few other spots. It is commonly smoother than g. incurva, and considerably broader, with a lobe on one side. The lobe is sometimes very faintly marked, but is more frequently distinct. Shells of this species are found in a seam of yellow sandy marl, at Rowlston scar, not petrified, but preserved; while others occur there petrified, in the calcareous sandstone.—A shell like g. incurva, deeply striated or sulcated transversely, occurs in the chalk; but we have not ascertained its genus.

Perna. Shells of this genus, resembling those figured by Sowerby, Tab. 66, but much larger, occur in the oolite, at Thornton and other places. They are apt to be confounded with the solens; especially as it is very difficult to obtain a complete specimen, the shell being converted into a brittle spar.

Pinna. This shell is not very abundant in our strata, yet we have two or three distinct species.

No. 5, Pl. X, occurs in the calcareous sandstone under the oolite, at Scarborough, Falsgrave, Silphoue moor, and other places. It is bent and tapering, like a goat's horn, which it resembles in colour, and in its angled shape, the middle of each valve rising in a longitudinal ridge, so that the cross section is somewhat quadrangular. It has longitudinal striæ, or slender ribs, towards the beaks; but the ribs gradually become obsolete, and entirely disappear towards the base; where it is marked with transverse striæ and wrinkles. The shell is often much wrinkled, presenting a rugged appearance, especially near the base, which is rather truncated. The two valves, in the specimen figured, are parted near the base, where the shell is very thin. It is six inches and a half long, and the base is two inches and a half broad. This species resembles the *p. incurva* of Linnæus, but may be fitly named *p. capricornus.*

No. 6 displays the inside of a valve of an elegant pinnite, from the lowest shale at Robin Hood's Bay. It occurs in the same shale

at Boulby and Huntcliff. This fossil reaches fifteen inches or more in length, but seldom exceeds four inches in breadth; being an oblong shell, rounded at the base, and greatly resembling a lettuce leaf. As the shell is thin and brittle, perfect specimens can rarely be obtained. Each valve is marked, near the beak, with numerous longitudinal ribs, which grow obsolete before reaching half way to the base, giving place to transverse striæ, or lines of growth. The inside is smooth, or slightly waved across, having a pearly aspect; the beauty of which is increased when the shell is pyritous. The shell is more straight, thick, and rounded, than No. 5; but the specimens are usually found much compressed and broken. It is perhaps a variety of the *p. rotundata* (or *gigas*); if not, we may term it *p. folium.*

A small pinnite, still more rounded, its section being quite circular, occurs in the Staiths beds; but we have not seen an entire specimen.

UNIVALVE UNILOCULAR SHELLS.

Of this division of shells we have no great variety to produce; for though immense quantities of univalves occur in the oolite, we do not find so many different genera and species as might be expected. Of the numerous genera, *conus, cypræa, bulla, voluta, strombus, murex,* and *helix,* we have scarcely an instance. A few specimens of cones are said to be found in the oolite. Mr. Parkinson (III. p. 56) mentions a very fine volute, which he supposed to be from the neighbourhood of Whitby; but we have discovered nothing of the kind. Shells resembling the *murex erinaceus,* the *m. antiquus,* and the *m. corneus,* occur in the oolite; but we have not been able to identify them.—A few genera of this class may be noticed as decidedly occurring.

Buccinum. *Whelk.* No. 3, Pl. XI, may be assigned to this genus, though the lips and beak are too imperfect to enable us to speak with certainty. Like *b. flammeum* of Dillwyn, it is longitudinally plaited and transversely nodulous; having two rows of large tubercles on the body whirl, and one row on each of the other whirls. The plaits are undulated, but are somewhat defaced. This shell, which is from the oolite, measures above two inches long, and nearly two broad.—*B. undatum,* to which this shell bears some analogy, is said to be found on Langton Wolds.—The large cast, Fig. 9, greatly resembles *B. striatum;* yet it probably belongs to the next genus.

Turbo. *Wreath,* or *Whirl.* Under this genus may be placed several shells found in the oolite; some of which belong to the new genus melania. Of this the shell, Fig. 9, last named, is an example; being evidently the *melania striata* of Sowerby, Tab. 47. Mr. Sowerby, by putting two fragments together, belonging to specimens of different sizes, has made his figure of too long a shape. The shell, or rather the cast, is pretty common at Pickering and Malton. Some specimens are from six to eight inches in length, and between three and four in breadth.—Fig. 7 is the cast of a small shell, nearly the same in shape, but quite smooth, and no doubt of a different species. It is rather rare.—Fig. 8 is a handsome cast, very like the *t. tumidus* of Pennant. It is akin to the helix family, and resembles the *phasianella angulosa* of Sowerby, Tab. 175. Some shells, similar to this, approach the *t. littoreus.*

Vast numbers of our tapering oolite shells may be assigned to this genus; many of them resembling *t. terebra,* others more elongated, in the form of *buccinum strigilatum.* Of such it is extremely difficult to obtain more than the cast, the shell itself being a brittle spar. No. 10 is one of the most common species. It greatly resembles the *melania Heddingtonensis* of Sowerby, Tab. 39; having a kind of

elevated band at the upper part of each whirl; but it is smoother than his shell. It is often four inches, or upwards, in length. Shells of the same form are found, without any appearance of a band at the sutures.—No. 11 is a more elongated shell, nearly corresponding with the *turritella conoidea* of Sowerby, Tab. 51, Fig. 1, 4; or his *t. elongata*, Fig. 2, obviously a variety of the same species. There is a slightly elevated thread at the suture, on the upper side of each whirl; but in many specimens the thread is scarcely, if at all, discernible. Other shells of this form resemble Sowerby's *turritella edita*, Tab. 51, Fig. 7. Almost all these shells are finely striated across, that is, spirally, in the direction of the whirls.—Shells of the same form occur, but rarely, in the dogger; where also we find others resembling No. 8. Minute shells, like the latter, are seen occasionally in the lias and pyritous nodules.

Trochus. *Top-shell.* Shells of this genus occur in the oolite, the grey limestone, the blue limestone, the dogger, and the Staiths band. No. 4, Pl. XI, from the blue limestone, resembles *t. zizyphinus*, but is differently marked; and having the appearance of an umbilicus, it may be more akin to *t. radiatus*. The granules of the numerous transverse striæ are connected by slender threads. The aperture is rhomboidal; and the base is flat, or a little convex, and marked with concentric lines. The markings in the specimen are somewhat worn off. We found also in the blue limestone, an imperfect cast of a large trochite of the same shape, above three inches in diameter, with an oblique or spiral umbilicus.—No 1, from the Malton oolite, resembles *t. magus*, being a flat shell, striated transversely, and with the whirls plaited on their upper margins. It is near two inches broad, and little more than one inch deep.

Fig. 6 represents the cast of a large shell from the grey limestone, which has measured nearly four inches in breadth, and above two in depth. Though resembling a trochite, particularly *t. concavus*, it

more properly belongs to Sowerby's new genus EUOMPHALUS, Tab. 45, 46, 52; or rather, as the aperture has not been angular but quite round, it may be assigned to his genus CIRRUS, Tab. 141; although the spire is much more flat than that of any species described by him. It has a deep and wide umbilicus, displaying the interior of the whirls.—The Scarborough Catalogue, after Mr. Parkinson, notices shells of this kind under the genus DELPHINULA.

NERITA. *Nerite.* To this genus must be assigned No. 2, Pl. XI, from the oolite, two inches long, and of equal breadth. It has some resemblance to *n. glaucina*; but as we cannot speak with certainty, either of its umbilicus or its lips, we shall only add, that it is a smooth shell, except that the body whirl is marked with the lines of growth, and a few faint transverse striæ at the base. Perhaps we should consider it as *n. maxima* of Dillwyn.—No. 5 is a beautiful little shell, also from the oolite, of a yellow colour, deeply cancellated. As the aperture is marginated, it is akin to *n. marginata* of Dillwyn, if not the same species.

PATELLA. *Limpet.* No. 12 is a small limpet, pretty common in our lias nodules. Sowerby names it *p. lævis*, Tab. 139, Fig. 3, 4.

DENTALIUM. *Tooth-Shell.* No. 13 is a group of dentalia from the lowest shale, belonging to *d. entalis*, or a species akin to it. These shells are often found compressed and broken. The inside is a white spar, frequently decomposed. Dentalia, both round and angular, occur in the oolite.

SERPULA. Numbers of serpulites, in almost all their multifarious shapes, occur in the oolite, the alum shale, and other strata, generally adhering to other shells. No. 14, from the dogger at Peak, is a group of serpulites, of a species resembling *s. afra*, having about three whirls. A similar shell is figured by Parkinson, III. Pl. VII. Fig. 8. The same serpula occurs in the upper shale.

We now proceed to a division of shells comprising an immense number of highly interesting petrifactions; viz.

MULTILOCULAR SHELLS.

This division includes three grand families, or genera, the ammonites, the nautilites, and the belemnites; in all of which, the shell is divided internally into numerous chambers. The body of the animal has lodged in the outer chamber, but has communicated with the interior chambers by a tubular substance called the *siphuncle*, which has pierced through all the septa, or partitions. By inflating or compressing this tubular substance, the animal has had the power of raising itself to the surface of the water, or sinking to the bottom.

Cornu ammonis or Ammonites. *Ammonite* or *Snakestone.* We place this genus in the front of our multilocular shells, both because it is the most abundant, and because it is that for which Whitby has long been celebrated. Who has not heard of the fame of our *petrified snakes*, renowned both in fable and in song? The shells of this genus have acquired the name of *snakes*, from their resemblance to serpents coiled up. Indeed they were long supposed to have been real snakes; and the want of heads was no valid objection to the hypothesis, since monkish tradition alleged, that the whole race of serpents, by which the territory of Lady Hilda had been infested, were at once decapitated and petrified, through that good saint's prayers! *

Small shells of the *helix* genus, or rather of the new genus *planorbis*, are found recent in the river Tees, greatly resembling our ammonites in their outward form, but they are not divided internally into chambers. Notwithstanding the great number and variety of the fossil ammonites, scarcely one species has hitherto been discovered recent.

* See History of Whitby, I. p. 213.

Shells of this genus are found in all parts of our aluminous strata, but especially in the main bed of alum shale. The best specimens are procured from the pyritous or lias nodules; but great numbers are found disengaged. In several places near Whitby, the scar seems paved with them; and the pavement has a rich appearance where they are coated with shining pyrites. Most of the shells that are found without a nucleus are imperfect, the inner whirls being decayed, or the whole shell being broken and flattened. It is observable, that they are almost always found in the plane of the strata, their flat surfaces being parallel to the horizontal partings; a remark which applies to our fossil oysters, and other flat shells, as well as to the flat pieces of fossil wood.

Ammonites are found also in the lower chalk, the upper shale, the second shale, the oolite, the grey limestone, the calcareous sandstone, and in a few of the ironstone beds. We have observed about thirty different species, of most of which we have given specimens in Plates XII, XIII, and XIV.

No. 3, Pl. XII, is the most plentiful of our ammonites, and is hence called by Sowerby *ammonites communis*, Tab. 107, Fig. 2, 3. The aperture is round; and its edge, or lip, when entire, is reflected or partially folded back, like the edge of a trumpet or a bell; as is the case in some species of the helix family. The ribs are numerous, and generally sharp, and each of them at the back is divided into two, or a short rib comes between every two long ribs. The shell has generally five or six turns; but in this respect, as well as in the closeness and sharpness and curvature of the ribs, there is much variety. This species abounds in the main bed of alum shale. It seldom reaches four inches in diameter.—A shell, apparently of this species, or approaching very near to it, occurs in the lower chalk, and in the upper shale, where it is generally in a highly nacrous state.—An ammonite greatly resembling this species, but much flatter, and often of a larger

size, occurs in the grey limestone at Malton.—The *a. angulatus* of Sowerby, Tab. 107, Fig. 1, which occurs in nodules in the alum shale, is on the contrary a much thicker shell than *a. communis,* though the ribs have nearly the same form.

No. 8 also resembles No. 3, both in size and in form; but differs from it in being rather more flat, and especially in the slenderness of its ribs, from which we may name it *a. tenuicostatus.* Like *a. angulatus,* it is not very plentiful.

No. 1 is very abundant in the alum shale, and often attains a great size, measuring six or eight inches, or upwards, in diameter. It is the *a. Walcotii* of Sowerby, Tab. 106. We would rather name it *a. Hildensis,* in honour of our Lady Hilda. It is more flat than *a. communis,* and has fewer whirls. The back has a keel between two furrows. The ribs are somewhat sigmoidal, especially near the mouth, where the shell when entire also displays minute sigmoidal striæ. A furrow, more or less deep, usually divides each whirl into two parts, and on the inner part the ribs are rather faintly marked. In this respect, however, there is much variety in the shells of this species. Most specimens are only casts, and display the elegantly ramified edges of the septa, resembling flowers. The original shell appears from its remains in some specimens, to have been of a chocolate brown colour, handsomely spotted with white.

No. 2 is a very reduced figure of what we may call *a. ingens,* being one of our largest ammonites. The specimen is from the oolite at Pickering, and measures fourteen inches broad, and four in thickness at the aperture, which is nearly round, with a slight approach to quadrangular. It weighs twenty-nine pounds. The ribs are strong, but not very numerous, and are discontinued on the back: in which respect it differs from *a. giganteus* (Sowerby, Tab. 126), a large shell which also occurs in the Pickering and Malton oolite; the ribs of which are very numerous, and each of them on the back is parted

into three or four slender ribs. The same, or a similar shell, occurs in the upper shale. Another very large shell is met with in the oolite and the grey limestone, resembling *a. ingens,* but having the aperture more square, and the ribs more acute, each of which terminates towards the back in a sharp knob. This shell, of which we have no entire specimen, may be termed *a. acuticostatus.*

No. 12, Pl. XIV, is a much smaller shell, from the blue limestone, or rather from alluvial nodules of blueish limestone, having also very sharp ribs, but continued round the back; and having the aperture round. The original shell is brown with some white spots, as in *a. Hildensis;* so that we may name this species *a. maculatus.* A similar species, or a variety of the same species, also from the alluvium, has on the sides two small knobs upon each rib; the one towards the back, and the other, which is the smallest, towards the inside.

No. 13, Pl. XIV, has also sharp ribs, and has a sharp keel running along the back. It occurs in the lowest shale at Robin Hood's Bay, and other places. A large shell generally found imperfect, but apparently of the same species, occurs in the Redcar rocks. The *a. Bucklandi* of Sowerby, Tab. 130, seems to be a cast of this species. We would prefer naming it *a. Redcarensis.*

No. 6, Pl. XIII, is a very small but handsome ammonite, also from the lowest shale, and common in Robin Hood's Bay. Its ribs are sharp on the sides, but thick and flat on the back. As it is generally found in a pyritous state, shining like gold, we might call it *a. aureus;* but it seems to be the same with *a. planicosta* of Sowerby, Tab. 73.

We have met with no shell corresponding exactly with Mr. Sowerby's *a. armatus,* Tab. 95; which he states to exist in our alum shale, in numerous varieties. We have several distinct species of knobbed ammonites, but have seen none with striated knobs, stuck on like barnacles or small patellæ, as in the outer whirl of Mr.

Sowerby's shell. We must therefore suppose, that the latter is so rare, that it could not be found among all the thousands of specimens which we have examined; or that Mr. Sowerby has been misinformed as to its locality; or, which seems most likely, that he has made out his figure by combining two specimens together, of which the outer one has not belonged to our alum shale, and the inner one has had some of its knobs altered, to connect it with the other. No. 9, Pl. XIII, is the inside of Sowerby's *a. armatus*, with a little variation in the knobs, which are not striated but plain, and rather sharp. The specimen appears to be nearly entire, and we have no reason to think that it has had another whirl, like that in Sowerby's figure. Yet in tracing the spire in its several volutions, we see, as in his shell, a succession of different markings. Towards the mouth, the ribs are alternately knobbed and plain, and the knobbed rib parts into three at the back, immediately beyond the knob, while the plain rib goes round the back single. At the distance of half a whirl from the mouth, the single ribs disappear, and each knob is connected with a double rib, resembling a loop attached to a button; each double rib passing into three or four on the back. This kind of marking, common to most of our knobbed ammonites, continues inward through the next two whirls; beyond which, the knobs gradually disappearing, the interior part of the shell is plain, and fine ribbed. This part greatly resembles small specimens of our *a. tenuicostatus;* but the latter is a distinct species, growing to a considerable size. We have one entire specimen, above three inches broad, with part of the reflected lip.

No. 11, Pl. XIV, is a shell with similar markings, but of a species quite distinct; for the spire, instead of being nearly rounded, appears as if greatly compressed from the back inwards, and the interior shews a deep cavity on both sides, the outer whirls forming a high border around it. Besides, the button and loop marking does not give place to plain ribs in the interior part, but continues towards the

centre. Its knobs are more strong and prominent than those of the last shell.—No. 3, Pl. XIII, is another distinct species; and it is the most common of our knobbed ammonites. The button and loop marking continues to the centre, as in the last shell; but the centre, though depressed, is far from being so deep; the body of the spire is more round, the knobs are generally much smaller, and the ribs finer. —If we name No. 9, Pl. XIII, *a. armatus*, we may call this species *a. subarmatus;* and No. 11, Pl. XIV, *a. perarmatus.*—We have a fragment of a large shell, that has measured four inches in diameter, of a species closely allied to a. subarmatus, but thicker, and more deeply umbilicated. It has the termination of the outer whirl, shewing a part of the reflected lip; but instead of resembling the outer whirl of Sowerby's a. armatus, it is marked with very small and simple knobs, less than those of the next whirl. Perhaps it is only a variety of a. subarmatus.

Figures 4 and 5, Pl. XII, represent fragments of two knobbed ammonites that are rare and singular. No. 4, which is from the lower part of the aluminous strata, is part of the outer whirl of an ammonite that has measured about ten inches in diameter. Its aperture or section is subtriangular, the back being not rounded but with two acute angles, and the sides sloping inwards, especially one side, which is more strongly ribbed and knobbed than the other. The knobs on the plainest side, in this specimen, consist chiefly of galena, a substance which we noticed (p. 124) as occurring in the dogger, and which is not uncommon in the petrifactions of the aluminous strata.— No. 5 is from the calcareous sandstone below the oolite, on Silphoue moor. It has belonged to an ammonite equally large, and with larger ribs and knobs, placed at greater distances. The back is somewhat rounded, and that and the intervals between the ribs are striated, whereas in No. 4 they are smooth. Unless more appropriate names can be found, when entire specimens are obtained, No. 4 may be termed *a. subtriangularis*, and No. 5, *a. Silphouensis.*

The markings of No. 9, Pl. XII, resemble those of a. communis, and still more those of a. giganteus. Like the latter, it is from the oolite, and is of a great size, our specimen being eight inches broad, and two thick; but it differs from a. giganteus, in having the exterior whirl vastly larger than the next, which it partly conceals, as is the case also in No. 1. This shell we may name *a. Pickeringius.* Sowerby's *a. Nutfieldensis,* Tab. 108, resembles it.

This shell and a. Hildensis make a distant approach to the nautilus family, in having a very large outer whirl, partly concealing the interior whirls. This remark applies much more to the ammonites that remain to be described, which ought perhaps to be arranged under a new genus, distinguished by the appropriate name AMMONAUTILUS, as suggested by Mr. Parkinson.

No. 7, Pl. XIII, corresponds with the *a. elegans* of Sowerby, Tab. 94, Fig. 1; having the same form, the same sigmoidal ribs, sharp keel, and truncated internal angles. It is not uncommon in the lias nodules. The specimen figured is small, but singular, having portions of the chambers hollow, containing when discovered a considerable quantity of oil.—No. 8, Pl. XIII, greatly resembles this last shell, and has the same localities; but the internal angles of the aperture or spire, instead of being truncate or bevelled, are sharp and rather prominent, the margin of the outer whirl projecting somewhat over the next whirl. There is also a groove, as in a. Hildensis, generally dividing the whirl longitudinally, or rather spirally. This shell is often pyritous, and of great beauty. As it occurs chiefly on the shores of the Mulgrave estates, we may name it *a. Mulgravius.*—No. 4, Pl. XIII, belonging to the same strata, differs from No. 7, chiefly in having the internal angles rounded, giving the aperture an oval form. Hence we may call it *a. ovatus.* It differs from the *a. ellipticus* of Sowerby, Tab. 92, Fig. 4, in having sigmoidal ribs.—No. 5, Pl. XIII, also from the aluminous strata, appears to be

a small specimen of Sowerby's *a. concavus*, Tab. 94, Fig. 2. It has a faint spiral furrow on one side.—We have another shell with the same kind of strong waved ribs, but having the internal angles of the aperture sharp, as in No. 8. This species, which is also from the alum shale, and which is not figured, may be named *a. Boulbiensis.*

No. 6, Pl. XII, is of a different character from the five species last described. Its spire is not flat, but rounded, and without a keel, the aperture being nearly circular; and its ribs, or rather striæ (for they are very small) are not sigmoidal, but straight. It greatly resembles the spiral horns that are used as snuff-boxes; and as it is generally found in the state of cast, with the beautifully foliated septa displayed, it has a rich appearance, especially when it is pyritous. This species, which is from the alum shale, we may name *a. cornucopia.*

No. 10, Pl. XII, and Nos. 10, 11, Pl. XIII, approach still nearer to the nautilus family, having only a small part of the inner whirls exposed. They differ from the ammonites already described, in having crenulated keels.—No. 10, Pl. XII, is found in the oolite and the grey limestone of Malton. It is a lenticular shell, with a sharp crenulated keel, and sagittate aperture; having half the outer whirl marked with large and distant ribs; and the other half, towards the keel, with numerous curved small ribs. The *a. splendens* of Sowerby, Tab. 103, is marked like it; but, as it does not fully coincide with it, we may name our shell *a. Maltonensis.*—Another shell of the same shape, but with slender striæ instead of ribs, is also met with in the Malton limestone. It seems to be Sowerby's *a. excavatus*, Tab. 105. This species and the last are nearly of the same size, each measuring four or five inches in diameter.—No. 10, Pl. XIII, is a rare and beautiful little flat shell, from the calcareous sandstone of Rowlston scar. It has on the back a double crenulated or serrated keel, or rather, a double row of minute knobs, with a narrow space between the rows, rather depressed. The knobs are at the ends of its waved

ribs, which are numerous towards the back, but fewer and more prominent towards the inner side of the whirl. The aperture approaches to ovate. Sowerby's *a. Calloviensis*, Tab. 104, Fig. 3, and *a. Duncani*, Tab. 157, resemble this shell; but as they both differ from it, we may name it *a. Rowlstonensis*. A beautiful nacrous shell, not unlike this species, occurs in the upper shale; but we have no complete specimen.—No. 11, Pl. XIII, is another small, beautiful, and rare ammonite, from the beds corresponding with the Staiths band in the front of Cranimoor. It resembles *a. Maltonensis*, both in its shape and its markings; but its ribs are waved, and are less prominent, and extend across the whirl to near the crenulated keel, where they bifurcate. We may name this shell *a. Clevelandicus*.

A very large globose smooth ammonite, with a deep cavity or umbilicus on each side, occurs in the Malton oolite, which, from the great size of the cavity, may be named *a. capax*. Sowerby's *a. sublævis*, Tab. 54, resembles it, but is not the same species.—A few more species of the ammonite family are described in the Scarborough Catalogue.

NAUTILUS. The difference between the ammonite and the nautilite is merely this, that in the former all the whirls are exposed, while in the latter the outer whirl conceals all the rest. We have dismissed the ill defined genus AMMONOIDES, under which some authors include part of the ammonites last described; and we have contented ourselves with naming the proposed genus AMMONAUTILUS, intermediate between the ammonite and nautilite; because it would be difficult to fix the limits of such a genus, there are so many gradations between those species in which the whirls are fully exposed, and those in which they are almost entirely concealed. In like manner, the transition from the latter to the umbilicated nautilus is so short,that there is perhaps an impropriety in making even the nautilites a distinct family. We may notice, however, that in general

the siphuncle is more conspicuous in the nautilite than in the ammonite; and whereas in the latter it commonly runs along the back, particularly in the keeled species, in the former it is usually near the middle of the whirl.*

No. 2, Pl, XIII, may be termed *nautilus pompilius;* for it so nearly corresponds with the recent nautilus of that name, that it may be viewed as a variety of the same species. Sowerby's *n. imperialis,* Tab. 1, almost coincides with our shell; but the siphuncle in our specimens is more central, as in the recent shell. There is, however, considerable variation as to the disposal of the siphuncle, both in recent and fossil specimens. This species, which is found in our aluminous strata, rarely displays the shell entire, the exterior being so far gone, as to shew the edges of the septa; from the curved form of which, it is denominated the *lobster-tailed nautilus.* It sometimes is near a foot in diameter.—The *n. scrobiculatus* of Dillwyn, which is very like *n. pompilius,* is a recent ammonite, shewing the interior whirls.

No. 1, Pl. XIII, is the most common of our nautilites. It is a flat umbilicated discoidal shell, often of a large size; the specimen figured being sixteen inches broad. The aperture is somewhat ovate, the back being rounded; the sides towards the mouth are marked with prominent ribs or undulations, which grow obsolete before arriving at the back, and also gradually diminish in size as they recede from

*It may be proper to observe, that what we call the *back,* viz. the exterior edge of the disk, corresponds with what Mr. Sowerby names the *front.* We reject Sowerby's definitions of the two genera, taken from the undulations in the margins of the septa; because the characters of a genus should be drawn from perfect specimens, not from imperfect; and the margins of the septa cannot be seen, till the shell itself is destroyed or removed. Besides, great confusion must arise from admitting Mr. Sowerby's distinction; and hence he himself has not strictly adhered to it. We have an instance in *nautilus truncatus,* Tab. 123, in which the edges of the septa are finely foliated, though the ribs or striæ, which he seems to confound with them, are straight.

the mouth, till they entirely disappear. The ribbed part indeed is wanting in most specimens. The whole shell, both where it is ribbed and where it is plain, is striated from the umbilicus outwards, the striæ being continued round the back; but very often the shell is partially gone, and the foliated edges of the septa, which are arranged in the most elegant form, are displayed in all their beauty; as may be seen in part of the specimen figured. This nautilus, like the former, is found in our aluminous strata, particularly in the main bed of alum shale. The siphuncle runs along the back, in which respect, and in the aperture, it differs from Sowerby's *n. truncatus*, Tab. 123; which, however, by his own account, was figured from fragments of different specimens, part of which, we suspect, might coincide with our shell. As there is nothing truncate in our fossil, we shall name it *n. Whitbiensis.*

Fig. 7, Pl. XII, represents a rare and handsome umbilicated nautilus, also from the alum shale. It is distinguished by a flat space running along the back, divided in the middle by a slight ridge, or imperfect keel. The sides are marked with fine striæ, and with irregular undulations; and the edges of the septa, where exposed, are beautifully foliated. This species is not so flat as n. Whitbiensis, nor so globose as n. pompilius, and is much smaller than either. *N. lineatus* of Sowerby, Tab. 41, resembles it, but is obviously another species. From its imperfect keel, we may designate our shell *n. subcarinatus.*

Polished sections of nautilites or ammonites, from the aluminous strata, are often very beautiful and interesting; the chambers being filled with a light coloured spar, while the septa and exterior shell are of a darker colour. The mixture of pyrites sometimes adds to their beauty, though the highly pyritous specimens do not take a good polish. In some sections, particularly those of the lobster-tailed nautilus, the siphuncle is finely displayed.

One or two species of nautilus are said to occur in the oolite, but we have not seen any genuine nautilites in that kind of rock.

Belemnites. *Belemnite or Thunderbolt.* This is one of the most singular shells in existence, and having no recent analogue, except perhaps a few microscopic shells, it is difficult to ascertain with precision what it has been in the recent state, especially as it is rarely, if ever, found entire. The chambers, instead of being disposed spirally, are arranged one above another, so as to form a cone, more or less tapering; the septa being a series of cups, very small towards the apex of the cone, and increasing in size as they approach the base or mouth. These cups, like the septa of the recent nautilus, have their hollow sides towards the mouth. In the last and largest of them, which probably had some peculiar margin, the animal has lodged, maintaining a communication with the other chambers, by a siphuncle that pierces all the cups or septa, and has no doubt served, like the siphuncle of the nautilus, to regulate the ascent and descent of the animal in the water. The process has perhaps been facilitated by a singular appendage belonging to the shell, enveloping the conical part like a sheath, extending beyond it, in a cylindrical or rounded form, and at last tapering to a point. This appendage, which varies in shape, is always found in a sparry state, and the cross fracture displays a number of lines radiating from a centre, like a star. The centre of the star is not always in the middle, but often approaches to one side; being determined by a line passing from the apex of the chambered cone, to the exterior apex, or point of the belemnite, which line is not always central. The part that envelops the chambered cone is radiated from the surface of the cone outwards. The exterior surface of the belemnite is generally smooth, and has more the aspect of horn than of shell, especially as it is often translucent. Under certain circumstances it acquires a rich silky or pearly lustre.

The chambered cone, which is called the *alveolus*, is not only enveloped by this radiated appendage, but has a thin shelly coating of its own, concealing the edges of the septa and the chambers. Towards the mouth, this is the only covering of the alveolus; for the radiated envelope grows thinner and thinner, in proportion as the cone enlarges, till the latter becomes fully exposed. Such at least is the case in the fossil shell; in which also the inner covering of the alveolus is often found decomposed, so that the edges of the cups and the chambers appear. The latter are generally extremely small, their breadth being less than the thickness of the cup on either side.

The alveolus is often highly pyritous, the septa appearing like golden cups, and the shelly coating having the same splendid lustre; which is never the case with the radiated part of the fossil. Yet the latter is the most firm and durable part, for it is generally entire, while the former is more or less mutilated, often compressed, and very frequently altogether lost. The alveolus, in many instances, is found detached from its radiated sheath; though this does not occur so often in our strata, as in some other countries. In this detached state, the alveolus has been viewed as a shell of another genus, called ORTHOCERA, a genus which we have no hesitation in rejecting. Mr. Sowerby, who adopts the term as comprehending the belemnite family, judiciously intimates, that the orthoceræ which are considered as too large to belong to any known belemnite, may have had a thinner and shorter envelope which has been lost. Some of our alveoli expand to such a size, as to seem greatly too large for their belemnitic terminations, which only cover about half their length.

No shell is more extensively diffused in our rocks than the belemnite. It occurs in all our strata, from the upper chalk to the lowest shale, except the siliceous sandstone, the sandy and bituminous shale, and the coal. It is most abundant in the aluminous strata, the upper shale, and the calcareous sandstone.

No. 1, Pl. XIV, is the most common of our belemnites. It abounds in the alum shale, and in the calcareous sandstone; though in the latter, as also in the dogger, the belemnite has in many instances been decomposed, and nothing but the cast left. The cast is of a singular description; the radiated part, or sheath, being entirely gone, and its place left empty, while the cast of the chambered part, or alveolus, projects into the oblong cavity. The specimen figured has a great part of the alveolus laid bare, exposing the edges of the cups. Fig. 3 is a longitudinal section, shewing the manner in which the point of the alveolus terminates in its radiated sheath. This belemnite is sometimes ten or twelve inches long, and two inches across, at the broad end. It is seldom quite round, being generally somewhat flattened on two opposite sides, so that its section is oval rather than circular. This compression is usually greatest near the point, from which a slight groove runs a little way along each of the flattened sides. Sometimes a third groove is seen on one of the intermediate spaces, which is often a little flattened, and in a few instances a fourth groove appears on the side opposite.—This species is named by Sowerby (Tab. 60. Fig. 1, 2, 3) *orthocera conica*, from the conical form of the alveolus, a circumstance not peculiar to this species. As it is the most common species, we may name it *belemnites vulgaris*. The mutilated form in which it commonly occurs, may be seen in the specimens figured in the mass of encrinite, Pl. V, Fig. 6.

No. 4, Pl. XIV, is a species nearly allied to No. 1. It differs from it, in being generally more blunt and more angular. It has one side very flat, the opposite side rounded, and the two intermediate spaces partially compressed. We usually find on each of those two sides a slight groove at the point, and on the flat side an oblong depression rounded at one end, as represented in the Figure. The apex of the alveolus, which is nearly central in No. 1, always inclines in this species to the flat side; as is shewn in the section, Fig. 5;

and hence, the line running internally, from that apex to the point of the belemnite, is nearest to the same side. For this reason, we may name this species *b. excentralis.* It is found in the oolite, the upper shale, and the chalk. The specimen, Fig. 4, which is from the oolite, is large, but imperfect. In its entire state it has probably been a foot long. The belemnites in the shale at Speeton seldom reach half that length; and are commonly much mutilated, the alveolus being lost.

No. 2 is the *b. fusiformis* of Parkinson. It is from the Speeton shale, and like all the specimens which we have seen, is imperfect, the conical broad termination, containing the alveolus, having been broken off at the narrow neck. The form of the entire shell may be seen in Parkinson's Org. Rem. III. Pl. VIII, Fig. 13. Our fossil sometimes displays two faint longitudinal furrows, or grooves, on opposite sides; but it is remarkably round and smooth. The internal line passing to the point is quite central; and the transverse section not only shews diverging rays, but concentric circles crossing them, as in some madrepores. In the Speeton shale, this fossil is often highly translucent, as is the case with b. excentralis, but in the Staiths beds, where we also discovered it, it shews the same dark grey and nearly opaque spar as the b. vulgaris. It occurs also, but rarely, in the lias nodules. Some specimens in the upper shale are very small; and hence they have been taken for spines of echini.

No. 6 is a very singular belemnite, from the alum shale at Saltwick, the only place where we have found it. The alveolus is conical and nearly central, as in No. 1; and, as in that species, is often replenished with pyrites and occasionally with galena: but the body, or sheath, is very long, slender, and cylindrical. Some of our specimens are about a foot in length, of which the alveolus occupies scarcely more than two inches; whereas in b. vulgaris, the alveolus is sometimes more than half the length of the entire shell. Another

peculiarity of this species is, that we never find it ending in a point, but in a flattened broad edge, like that of a chisel; as if the belemnite had terminated in an open tube, the sides of which have been compressed. This idea is corroborated by the fact, that the cross fracture towards this end shews no radiations, nor central line, nor any marks of a sparry structure. This species, which we have never seen described, may be named *b. tubularis*. In this, as in No. 1, the siphuncle is on one side of the alveolus: we have not seen the siphuncle in the two other species.

CRUSTACEA.

In the class of crustaceous animals, we have but few species to notice; and all of them are of the genus CANCER, or nearly allied to it.

Fig. 7, Pl. XIV, represents a rare and beautiful specimen of an animal allied to the lobster, or the prawn. The folds or plates of the tail are observable; but the head is mutilated. The rings on the body are numerous, and each of them has a row of minute spines on the front edge of it. A few similar spines are scattered on the tail part. The whole is of a rich blue colour. A small brown limpet adheres to the back. This fossil we found in a nodule in the Speeton shale.

No. 8 is another rare and interesting fossil of this family. It agrees so exactly with a large prawn, that we may consider it as one of that species. It was found near Malton, imbedded in the oolite; and now belongs to the valuable collection of Thomas Hinderwell, Esquire, Scarborough.

No. 9, from the same quarter, and the same collection, is also a beautiful fossil, which we may consider as belonging to another branch of the crab family. Only half of the shell is exposed in the Figure. It is of a blueish colour, and handsomely imbricated with prominent scales. At the broad end, the shell is in one large piece:

towards the narrow end, it is divided by grooves into various plates or pieces. This fossil and No. 8 are found imbedded together in the oolite.

No. 10, also from the Malton oolite, is nearly allied to No. 9; but is less divided towards the narrow end, where it is marked with six longitudinal rows of minute spines. The rest of the shell is marked with numerous punctures, or depressed dots, instead of having imbricated scales. Both halves of the shell are seen in the figure. An imperfect and distorted specimen is given on the Title-page of the Scarborough Catalogue.

Nos. 9 and 10 have obtained the name *beetles*, from their resemblance to the beetle tribes.

FISHES AND LARGE MARINE ANIMALS.

Under this head also we have few articles to introduce; but these few are highly interesting.

Of the finny tribes, those fishes which have hard scales are the most likely to be found petrified. A beautiful fish of this description has been recently discovered in the compact shale. Fig. 7, Pl. XVI, shews the head of this kind of fish, and part of the body; and Fig. 8, nearly the whole body, with about one half of the tail, and a portion of the head, or rather, of the gill-covers. This fish seems to belong to the genus ESOX (the *pike)*, several species of which have bony scales; and it seems most akin to the *esox Leverianus*, or the *esox Chilensis*. The head is rather compressed, and is shorter than in most pikes. It is covered with black, shining, bony plates, regularly and beautifully arranged; generally smooth, but marked in some places with raised dots or prickles, and branching lines. The frontal plates, and the plates next to the large gill-covers, bear most of these markings. The teeth are numerous, small, and sharp; as in most pikes. The body is covered all over with large and thick quadrangular

scales, disposed in oblique rows. These scales are generally brittle and easily detached; and are all covered with a dark brown or blackish enamel, giving the fossil a rich appearance. They are nearly rectangular in the thickest part of the body, but become rhomboidal towards the tail, where they also grow smaller. They are very handsomely imbricated, the middle of each scale lying over the junction between two scales before it. The front of each scale, or rather, one half of the front, is often more or less indented; especially where the scales are large. The tail has not been rounded, like that of the *esox osseus*, but sharp-angled and somewhat forked, like that of *esox stomias*. The rays of the tail are composed of numerous small joints. The large specimen, Fig. 8, has measured, when entire, two feet or more, in length; and about six inches or more, in its greatest breadth. The Figure does not shew the whole breadth, nor the proper shape, of the fish; but that of a pyritous nodule in which it is fixed. An oblong piece of pyrites is seen attached to the surface of the fish. The tail appears to have been about six inches broad, at its termination. The imperfect specimen, Fig. 7, has been a smaller animal; and might be about eighteen inches long, when entire. The fragment placed behind it has not belonged to it, but to another of the same size. In that fragment are the vestiges of a fin, but it is out of its natural position. In No. 7, and in a similar specimen, belonging to Mr. George Watson, there is a pectoral fin, much bruised.

Fragments of this kind of fish have frequently been found. They were considered as *glossopetræ*, or shark's teeth, till the specimens here mentioned were discovered.

Remains of fishes that seem to have belonged to the *ray* or *skate* family (the genus RAJA), have been found near Whitby, in the alum shale, particularly at Saltwick. Some specimens are very large; but they are generally so confused and imperfect, that we have not given a figure of any. One of our specimens might have been figured, to

shew the oddness of its shape, which approaches that of the human frame. It was brought us as the remains of a petrified child!

The most remarkable of our large petrifactions are the fossil remains of the animal now called the PROTEOSAURUS; formerly supposed to be the *crocodile*, or the *alligator*. A good specimen was found on the scar between Whitby and Saltwick, in 1758, when it was drawn and described by Capt. William Chapman and Mr. John Wooller. The description and drawing may be seen in the Philosophical Transactions, Vol. L; in the Gentleman's Magazine, Vol. 30; and in the Scarborough Catalogue. It measured twelve feet in length; but lay in a curved form, like a crescent. Another skeleton, fifteen feet long, was discovered on the scar, a little to the east of Staiths, in 1791; between which period and the publication of the History of Whitby, only a few very imperfect specimens were found, some of which are noticed in that work, Vol. II, p. 780. Since that time, the researches of the learned into the nature of these organic remains, and the eagerness of the public to obtain them, having much increased, a great number of specimens have been found. Within these three years, more than twenty skeletons, in various states, have been discovered and taken out of the alum shale, chiefly by the indefatigable industry of Brown Marshall, a carpenter belonging to Whitby; to whose labours we are also indebted for a variety of other interesting fossils. These large skeletons were almost all found near Saltwick, or between Saltwick and Whitby, in the main bed of alum shale; only a very few being discovered in the compact shale beyond Sandsend, and the lowest shale beyond Staiths.

For an acquaintance with the structure and habits of this fossil animal, the learned world is under great obligations to Sir Everard Home, Bart. His persevering researches have ascertained, that this animal, though resembling a crocodile, is more nearly allied to fishes —that it has lived in water, and moved by swimming, but has breathed

air—that its structure is analogous, in some respects, to that of the *ornithorhynchus paradoxus;* in others, to that of the *proteus*—and that it has curious paddles or fins, four in number, composed of a number of small bony substances, and bearing some analogy to the pectoral fins of sharks; with other interesting particulars, published in the Philosophical Transactions for 1814, 1816, 1818, 1819, and 1820. Sir Everard names the animal PROTEOSAURUS—the *lizard-proteus.* Perhaps it would be better to adopt another name, which also occurred to him, ICHTHYOSAURUS—the *lizard fish.*

The most entire specimen which we have obtained, and which was found in the compact shale only a few weeks ago (in October, 1821), is shewn on a very reduced scale, Pl. XV, Fig. 1. The head is a little imperfect, having been some time exposed on the scar. It lies on one side, displaying one of the eyes, but none of the teeth. The spine is remarkably entire, and contains, from its commencement to the point of the tail, one hundred and thirty two vertebræ. Some of these stand upright, some lie backward, and some forward; the whole having sustained a great pressure when imbedded in the shale, in consequence of which, part of the spine has been pressed forward upon the cranium. The whole skeleton, following the curvature of the spine, measures eight feet eight inches; of which length the head occupies nearly eighteen inches. The larger vertebræ are near two inches broad, and near one inch thick at the edge, the middle being very thin, as in the vertebræ of the shark. The ribs are slender and numerous, there having been more than forty on each side. They are all crushed flat, those on the one side being thrown across the spine, so as to meet those of the other side. Of the two fore paddles, or pectoral fins, only one is distinctly seen, at A; and it was partly injured in taking up the fossil. The two hind paddles are both seen at B, lying on the same side of the spine. They are much smaller than the fore paddles, being only about seven inches long, while the fore

paddle has been about ten inches, including the bone that looks like a handle. Behind the handles of the two small fins, are two flat oblong bones, with which they have articulated, and by means of which they have been connected with the spine, some other bones perhaps intervening. Sir Everard Home describes the animal as having a pelvis similar to that of the crocodile.

Fig. 2, Pl. XV, exhibits, on a larger scale, the imperfect remains of a specimen from Saltwick, which has been about the same size, the head being sixteen inches long, and having apparently lost about two inches of its length. The head is compressed laterally; but shews part of the teeth, and gives an interesting view of the eye, where we observe a circular bony plate inclosing a round cavity. If the bony ring corresponds with the iris, or the sclerotic coat, and the central cavity with the pupil, the eye must have been very large, the ring being above three inches in diameter. It shews no marks of crystallization, like what we see in some of Sir Everard Home's Figures. In this specimen, there are portions of both the pectoral fins, with some of the ribs, and a part of the spine.

No. 3 is an interesting specimen belonging to Mr. Geo. Watson. It was found between Whitby and Saltwick, in February 1819, within ten yards of the cliff, and very near the dogger. The head is a yard long, and has been some inches longer; and as we find in entire specimens, that the head is about a sixth part of the whole length, the animal when entire must have measured eighteen or twenty feet. The upper jaw has been pressed down upon the lower, and twisted a little to one side, displaying part of the inner surface of the lower jaw, and shewing several of the teeth. The teeth are conical, and smooth, or slightly ribbed; the cross fracture exhibiting concentric circles. The beak is pressed into a portion of the spine, which meets it at right angles: another fragment of the spine is found detached on the same side near the neck; but a much larger portion remains in its

natural position, behind the cranium, with which it is connected by a singular bone, corresponding with the *atlas* in quadrupeds. Several of the spinous processes are seen attached to the vertebræ behind the cranium, but thrown over to one side. These processes are not parts of the vertebræ, but distinct bones attached to them; and being easily separated, they are often wanting, or found detached. The canal for the spinal marrow is formed by a cleft passing through their bases, close to the vertebræ. The small processes of the tail vertebræ in No. 1, are very distinctly seen in the specimen, but too minute to appear in the figure. Their cross section resembles a spur.

No paddle was imbedded with No. 3; but the separate paddle, No. 4, was found near the same spot, and may have belonged to it. It exceeds seventeen inches in length, including the handle; and has been some inches longer. It has also lost part of its breadth. The arrangement of the small bones is somewhat obscured by portions of pyrites; and may be seen more distinctly in the imperfect fins of No. 2. Two bones are joined to the handle, three succeed, and are followed by four; and thus the rows, or phalanges, increase from the handle outwards, till they become seven or eight in some specimens; after which they again decrease, towards the end of the fin; the bones all along diminishing in size, according to their distance from the handle. The rows, and consequently the bones, appear to be most numerous in the larger and older animals. In the last specimen figured by Sir Everard Home, there is a fin composed of above two hundred little bones, forming eight phalanges in the middle of the fin. The largest pair of paddles found with any of our specimens, may be seen in Pl. XVI, Fig. 1. They are about the same size as No. 4, Pl. XV, has been; but are broader, having four phalanges. They are nearly in their proper position, as pectoral fins; but the skeleton to which they belong is very imperfect; the head, which is a yard long, being mutilated on one side, and the spine &c. greatly dislocated and

broken. It is curious to observe, that the pyritous mass in which the vertebræ &c. are imbedded, has assumed something of the shape of the animal, as in the fossil pike, Fig. 8, Pl. XVI.

On the top of the cranium in Mr. Watson's specimen, Fig. 3, Pl. XV, there is a deep hole, corresponding in situation with the blow-hole of the whale or the dolphin, which led us to conjecture, that the animal might belong to the cetaceous tribes; an idea which the form of its snout, its teeth, and its fins, might serve to corroborate; as we have noticed in the description of this specimen, published in the Memoirs of the Wernerian Society, Vol. III. We have not, however, discovered the same kind of hole in other specimens; on the contrary, the animal appears to have breathed by nostrils, rather than by a blow-hole. Faint traces of nostrils may be detected even in this specimen, and they are conspicuous in a fossil head in the collection of Mr. Hinderwell, Fig. 2, Pl. XVI; in which also may be seen, the sockets of both the eyes in their natural position, and a cross section of the snout. No. 3, Pl. XVI, is a fragment, shewing the way in which the teeth of the one jaw lock into those of the other.

The largest entire specimen lately found, measures fifteen feet four inches, if extended at length; but it only occupies thirteen feet four inches, two feet of the tail being bent back. It shews one hundred and forty four vertebræ; and has part of both pectoral fins, and of one of the small fins. The head, which is nearly a yard long, has been injured by long exposure on the scar. This interesting specimen, which was found near Saltwick, has been purchased for the Museum of the University of Edinburgh. Much larger animals must have been imbedded here, for vertebræ are found measuring five inches across, whereas those of this specimen are only about half that size, and those of Mr. Watson's three inches.

These fossil remains, however, do not all belong to one species. Considerable differences in the cranium, and other bones, have been

observed, and particularly in the vertebræ. Figures 4, 5, and 6, Pl. XVI, shew different kinds of vertebræ that occur. No. 4 is a bent piece of spine of the most common vertebræ, deeply cupped, and resembling those of the shark. Their thickness at the edge is only about half their diameter. No. 6 is a specimen of vertebræ much more oblong; their thickness, or length, being somewhat greater than their diameter. The vertebræ of the Whitby animal of 1758, appear to have been nearly of the same form and size, as far as we can judge from the imperfect drawing and description of them. Yet the ribs in No. 6 have been so much stronger than those of the common proteosaurus, and have been attached to the bases of the spinous processes in a manner so peculiar, that we doubt whether they can be assigned to an animal of this genus. The vertebræ, No. 5, can hardly belong to the proteosaurus; for their spinous as well as lateral processes are parts of the vertebræ, and not separate bones; and the spinous processes (which are mutilated in the specimen) are winged, as in quadrupeds, having oblique processes diverging from their bases. Besides, the canal for the spinal marrow is much larger than in the proteosaurus, and on the opposite side of the spine there is a flat or depressed space in each vertebra, marked with two holes. The length or thickness of each vertebra is less than its diameter; but the joints, instead of shewing deep cups, are nearly in the ball and socket form, to which also those of No. 6 approximate. No. 5, if not also No. 6, may therefore be assigned to some cetaceous animal, or perhaps to an animal of our next and last division.

QUADRUPEDS.

That the vertebræ, Fig. 5, Pl. XVI, may belong to a quadruped, is rendered probable from the discovery of a large scapular bone, together with an *os innominatum*, which could scarcely belong to a

marine animal. Charlton, in his History of Whitby, p. 355, states, that the skeleton of a horse was found in the alum shale at Saltwick, in 1762; but the correctness of that statement, and of his accounts of a complete human skeleton, said to have been discovered here in 1743, may be fairly questioned. We have heard similar accounts, of the discovery of bones of horses and of men in our alum shale a few years ago; but not from persons whose judgment could be relied on.

The remains of the ELEPHANT have been discovered in our alluvial beds; particularly the *grinders*, and the *tusks*, the most durable parts of that huge animal. Two grinders were found in the alluvium near Robin Hood's Bay about sixteen years ago. The largest is in the possession of Jonathan Sanders, Esq. It corresponds with the grinder of the Asiatic elephant; the masticating surface displaying twelve or thirteen double plates of ivory, alternating with a yellow bony substance. This surface is more than six inches long and three broad; the depth of the root, from that surface, is nine inches; and the diagonal or greatest dimension of the tooth, twelve inches. It weighed above thirteen pounds when found, but has lost a little of its weight and its compactness. The roots and angular parts had been rounded off by friction; and were further mutilated by the person who found it. Some of the plates nearest the root, as in the living elephant, do not run quite across, but display only their digitated processes in lines of rings; and the rudiments of newer plates appear in similar round processes, on the sloping surface descending towards the root; as may be seen in the drawing, Fig. 1, Pl. XVII. The small grinder found with this, is very compact, and has the roots; but its shape has also been injured by attempts to *improve* its appearance. It has belonged to a younger elephant, having fewer plates on the upper surface, and a greater proportion of them displaying rows of circles. Another grinder of a larger size, but less compact, was found some years ago near Lofthouse; and a larger

one, approaching to the size of the one figured, was discovered within these two years at Bridlington Quay. The latter has the roots pretty entire, and shews thirteen plates on the masticating surface.—Part of an elephant's tusk, eighteen inches long, and five in diameter at the broadest end, was taken out of the alluvial cliff near Scarborough spaw, some years ago. Similar fragments have been found at Bridlington and other places.

But the chief repository for the bones and teeth of quadrupeds in our district, is a cavern in the oolite, recently opened at Kirkdale near Kirkby Moorside; and we feel much pleasure in being able to gratify our readers with an account of this interesting spot.

We have already noticed (p. 68, 69) the caverns and fissures in the limestone about Kirkdale. Among the places where we had seen vestiges of fissures was the quarry on the side of the road, a little to the south-east of Kirkdale church. This quarry, which is wrought chiefly to procure stone for repairing roads, fronts the south or south-west, and is in the upper part of the eastern bank of Hodge beck, the stream that flows past Kirkdale church. Here the oolite strata gently dip towards the south, till they sink under the alluvial plain, less than a quarter of a mile to the south of this spot; and hence the banks of the stream, which are lofty at some distance above Kirkdale, are here scarcely higher than fifty or sixty feet. They present the same steep but smooth slopes as we find in the northern fronts of the oolite hills (see p. 64), the broken edges of the strata being covered with the alluvial soil, in which trees are here growing. The oolite at the quarry is of a hard quality, especially where it acquires a blueish colour; passing into a kind of blue or grey limestone, that is only imperfectly oolitic. We may here take occasion to introduce a remark, which should have been made before; that this blue and grey limestone, which we stated to occur usually *under* the oolite (p. 71, &c.), is often found in patches *in* the oolite, at a considerable

height; of which we have examples at Pickering, and in the quarry on the west side of Kirkdale church, as well as in this quarry.

In July last (1821), the labourers at the quarry, having removed the alluvium from above a fresh piece of the rock, in the north part of the quarry, and having wrought this rock downwards for a few feet, discovered an oblong opening or cavern, running horizontally from the slope of the bank eastward, and then making a turn to the north-east, in which direction it was found to penetrate far into the rock.

The operations of the workmen laid open that part of the cave which extended from the bank to the remarkable turn now mentioned, a distance of forty-six feet. The aperture towards the slope was nearly square, being about two feet each way; but it became considerably wider towards the turn, and a little higher. The stratum forming the floor was flat and unbroken, and was thickly covered with bones and teeth, not lying in distinct skeletons, but strewed about in the greatest confusion, and mixed with a soft marly earth, apparently resulting from the decomposition of bones. The bones had scarcely any appearance of being water-worn; a few of them were tolerably entire, but the greater part consisted of broken fragments of leg bones, thigh bones, jaw bones, &c.; and many of them were greatly decomposed, being nearly in the state of phosphate of lime, and ready to crumble into powder. The teeth were found, partly in the fragments of jaws, and partly detached. The quantity of bones, in this part of the cavern, was reckoned to exceed a cart-load. The roof and sides of the cavern were, in many places, incrusted with stalactites, masses of which were also mixed with the bones.

It is of importance to observe, that the mouth of the cave had no communication with the surface of the ground, being covered with the alluvial beds on the slope, consisting of two feet of fragments of limestone, or a kind of limestone gravel, which the workmen call *rubbish*, covered by two feet of yellowish marl and soil. The undisturbed

state of these alluvial beds clearly shewed, that *there never had been any hole or passage through them into the cavern;* but there were appearances of a small opening by which water may have flowed down the slope, *under these alluvial beds,* from the mouth of the cave, towards the beck, which is above a hundred feet distant, and thirty-six feet below the level of the cave.

From the entrance to the first remarkable turn, the cave had a slight bend upwards in the middle, ascending from the mouth, and descending towards the turn, where it is greatly enlarged. Here is the present entrance of the cave, which is three feet high and seven feet wide. The roof and the floor are both flat, and the latter is higher than the level of the floor on the outside, the broken edge of a stratum presenting itself as a step that must be ascended. Over this entrance the limestone rises to the height of ten feet, and it appears very compact, except a stratum of six inches forming the immediate roof of the cavern, which is cracked. The limestone is covered by five feet of alluvium, viz. three feet of *rubbish,* and two of marl and soil.

From the present entrance, the cave runs in a north-easterly direction, and for the space of about forty or fifty feet it gradually ascends, and contracts, the floor ascending rather more rapidly than the roof, while the sides also converge. At the time when the cave began to be noticed as an object of curiosity, and was first visited and examined by several gentlemen in the neighbourhood, and by one of the authors of this work, the cave had been penetrated no further than fifty feet in that direction. Since that time, however, the stalactites which obstructed the passage being removed, the cavern has been explored to the extent of one hundred and ninety-nine feet; making the whole length, from the original mouth of the cave, two hundred and forty-five feet.

From the strait part of the cave now mentioned, which is only two feet or two feet and a half high, the passage gradually descends,

and then rises a little, without enlarging much, till, at the distance of sixty feet from the present entrance, it opens into a kind of grotto, about six feet high, seven feet wide, and little more in length. From thence the passage makes a sudden turn to the right, but winding round a projecting part of the rock which is partly undermined, it presently resumes its former direction, in which it runs above forty feet, and then bends a little more towards the left. From the grotto to this bend, the floor is nearly on the same level; but the roof, instead of being flat, appears arched, the middle part of the strata above being gone, and their broken edges approaching each other at distances which gradually shorten upwards, till a solid bed seems to form the central part of the arch. Beyond the bend last mentioned, the passage has a considerable ascent for about twenty feet, leading to another chamber, where persons can stand upright. It has a higher roof than the first grotto, but is very narrow. Here a narrow fissure, in which also a person may stand upright, meets the main cavern from the right, at a very sharp angle, running southward and growing narrower as it proceeds, till it ends in a perpendicular crevice in the rock, on the south-east side of the quarry. The main cavern continues its north-east course for about eighty or ninety feet beyond this lateral passage, partly on the same level, but rather descending. Towards the extremity, it is much contracted, and its narrow dimensions, with the impediments occasioned by stalactites and fragments of the rock, have prevented its being explored any further. About half way between the opening on the right and the end of the cave, another branch is sent off on the left, in a north-west direction, leading towards the slope. It has been penetrated for about fifty feet or more, though a man in exploring it must crawl on his belly. The water which percolates through the roof at this end of the cavern, probably finds here a passage towards the beck or its subterraneous channel, like that at the first entrance of the cave, the place being damp and low.

Owing to the oozing of water through the cracks and pores of the rock, the roof and walls were found in most places incrusted with stalactites, forming beautiful pillars, icicles, and mammillæ or cones; some of them highly crystalline and translucent, shewing in their cross sections a radiated structure, like that of belemnites. Bones and teeth, mixed with marly clay, were found dispersed along the floor, especially in the broadest places, presenting the same appearance as in the first part of the cave. It deserves to be remarked also, that here, as in the celebrated caverns of Gaylenreuth in Germany, some bones were found on the sides of the cave, at or near the roof, incrusted with stalactites; a clear proof, that the caverns have been filled with water, which floating the bones, lodged some of them in crevices or on ledges towards the top, where, after the withdrawment of the water, they have been incased with stalactitic matter. Such bones, however, like those on the floor, are not *petrified*, but only *preserved*. It is scarcely necessary to add, that none of the bones are found imbedded in the rock itself, which exhibits only the shells most common in the oolite.

Though our cavern cannot bear a comparison with similar caves in Germany, in point of extent; yet it appears to surpass them and all other caves of this sort hitherto explored, in the variety of the relics entombed in it. The skill of a Cuvier would be requisite to assign them accurately to their several genera and species; but the following animals may be distinguished.

Elephant.—The grinders of the elephant occur in broken fragments; one of which, belonging to John Holt, Jun. Esq., shews two double plates, with part of other two, from the front of the tooth; which appears to have been of the same size as the grinder figured in Pl. XVII, No. 1. As the fracture is not recent, the tooth would seem to have been broken before it was deposited here. Several very large femoral and crural bones, some of which measure above six inches in thickness at the joints, probably belong to the elephant.

Rhinoceros. Figure 12, Pl. XVII, is a molar tooth of the rhinoceros, corresponding with that figured by Mr. Parkinson, III. Pl. XXI. Fig. 2. The masticating surface is above two inches long, and nearly two broad. Perhaps No. 7, Pl. XVII, may be a smaller grinder of the same animal; to which also several of the large bones belong.

Hippopotamus. We are not sure whether any of the teeth which we have obtained belong to this animal. Some of the large leg and thigh bones, that are very short in proportion to their thickness, may fairly be assigned to it. The existence of its relics in the cavern, we state on higher authority than our own, viz. on that of the Author of the Organic Remains, of whose valuable researches we have so often availed ourselves.*

Horse. The grinders of the horse have been found in considerble quantity; and several of them are in a state so sound and complete, that on receiving some of them, we at first suspected that a trick had been played by some *relic-monger*, till we ascertained them to be genuine.—No. 14, Pl. XVII, is a bone analogous to one of the

* Among those who explored the cavern, Mr. Gibson of Stratford, Essex, took an active part; and that gentleman having shewn his large collection of bones and teeth to Mr. Parkinson, the latter politely favoured us with his opinion of some of them. We are indebted also to the Rev. Jos. Smyth, A. B., the Rev. Wm. Eastmead, and Mr. Harrison, Surgeon, all of Kirkby Moorside, for many interesting specimens from the cavern, and much valuable information respecting it.

Here we may take occasion to observe, that all the Figures in the sixteen Lithographic Plates, illustrating the Organic Remains of the district, were drawn from specimens examined by the authors. Most of these are in their own possession; and for the use of others they have been principally indebted to Mr. Geo. Watson, and Mr. Henry Weatherald, Whitby; Thomas Hinderwell, Esq., Scarborough; and Mr. Waters, Bridlington Quay. The stone used for the Plates is that of the district, being partly from the Hildenley limestone, but chiefly from the blue limestone connected with the oolite at Pickering. The Figures, if inferior in beauty to those in some Geological Works, are on the whole superior in accuracy; as might be expected from this circumstance, that the whole process of drawing, engraving, printing, and colouring, has been done under the eye of Mr. Bird, and chiefly by his own hand.

fetlock bones of the horse; but it evidently belongs to a different, and probably a larger, animal. The Figure is less than half size.

Ox. No. 9 corresponds exactly with the innermost grinder on the right side of the under jaw of an ox, having the additional lobe belonging to that tooth. It differs from the same tooth in the stag, not only in size, but in shape; and still more from that in the horse, to which we at first assigned it. The animal must have been large, as the masticating surface is an inch and three quarters long, and three quarters broad. No. 10 is one of the half expanded molar teeth of a large ox, or of an enormous stag. It is the foremost grinder on the left side of the upper jaw. Many other ox teeth have occurred.

Deer or Elk. No. 13 is the root of a stag's horn, of a large size, being above three inches in diameter. The elk having been found of a prodigious size, the tooth, No. 10, may have belonged to it; especially as we have several large grinders, which appear, from their thinness, to be those of the stag, rather than of the ox. There are several bones which either animal may claim; such as the shank bone, No. 4; which is more than double the length and breadth of the Figure.

Hyæna. The remains of this carnivorous animal are by far the most abundant; particularly portions of the lower jaw, and the teeth belonging to it. No. 15 is a specimen of the left side of the under jaw, nearly entire; shewing the tusk, and four grinders; the last of which is sharp like an incisor tooth, and displays a double cone, having an additional lobe. The jaw is above six inches long.

Wolf or Dog. Fig. 2, Pl. XVII, shews the tusk on the right side of the inferior jaw of an animal of this kind; with two of the sockets of the incisor teeth. We have seen no other specimen.

Bear. Having obtained one or two large tusks, much greater than those of the hyæna, and of a form and size exactly corresponding with the bear's tusk from the German caverns, Parkinson's Org. Rem. III. Pl. XXII. Fig. 9, we do not hesitate to assign them to this genus.

PALÆOTHERIUM. The large tooth, Fig. 6, Pl. XVII, agrees so well with the description of the middle grinders in the lower jaw of this fossil animal, given by Mr. Parkinson, Vol. III. p. 382, 383, that we cannot assign it to any other. The outer surface shews two portions of cylinders, and the masticating surface, as well as the inner surface, shews the form of the letter W. The masticating surface is above two inches long; and hence the species must be the *palæotherium magnum.* No. 7, if not belonging to the rhinoceros, may be an upper grinder of the same animal; having the surface nearly square, with the same appearance of two cylinders on the outside, and of the letter W on the upper and inner surfaces. No. 8 has the same characters; but being much smaller, may be ascribed to a lesser species of palæotherium. The remains of this extinct animal have hitherto been discovered only in France.

No. 11, Pl. XVII, is part of a jaw with two grinders, of some unknown animal, about the size of a horse. The teeth are remarkably smooth, and nearly quadrangular on the upper surface; which, in the largest, measures one inch by three quarters.

No. 5 is a crural bone of an animal about the size of a hare, but with shorter and stronger legs.—No. 16 is a fragment of a rib, belonging to some animal about the size of a weasel.

No. 3 is a fragment of a hollow bone, of a very singular description, being the only fossil relic which we can assign to any of the feathered tribes. Small as the fragment is, its character is so well marked, particularly in its thinness, compactness, and translucency, that we do not hesitate to consider it as part of a *pinion* bone of a fowl, of the size and form of a goose, or a duck.

It is observable, that we have not seen, or heard of, any entire cranium found in the cavern; and few vertebræ and ribs have been met with. Among other specimens, we have examined an *astragalus,* or heel bone, greatly resembling that of a hare, but vastly larger; and some blade bones like those of the ox.

From the facts above stated, it would appear, that the animals whose bones have been discovered in the cavern, never lived there; and that their bones have been floated into it, in a shattered state, previous to the deposition of the alluvial covering. The same remarks may be applied to the relics in the German caves, and to those in the rock of Gibraltar, and in similar situations. These relics, with others found in alluvial beds, such as those discovered by Mr. Parkinson, at Walton, in Essex, have probably been all deposited at the same era. What that era was, will be considered in Part Third.

Kirkdale cavern is not the only fissure containing fossil bones, discovered in England. An instance of the same kind occurred a few years ago, in the limestone, near Plymouth; and the Rev. Professor Buckland, whose politeness we are bound to acknowledge, informs us, that he has recently found a similar deposit of bones in a cavern near Swansea. We are inclined to think, that other instances have occurred, which have not attracted the notice of the learned. Twenty years ago, or more, a fissure in the oolite was found a little to the north of Kirkby Moorside, containing great quantities of bones. The bones were presumed to be those of men and horses, and their accumulation there was considered as the result of a battle, and no further investigation took place.

We cannot close this part of our Work, without expressing our astonishment, at the rich variety and beauty of the animal remains discovered in our strata. Here, as in the living creation, the works of the Deity appear more beautiful and interesting, the more closely they are examined. Whether we survey the largest, or the most minute; whether we contemplate those whose beauty is chiefly external, as most shells; or those which are most beautiful in their internal structure, as madrepores, we see matter for the highest admiration, and the warmest praise. "Great and marvellous are thy works, Lord God Almighty!"

GEOLOGICAL SURVEY

OF THE YORKSHIRE COAST.

PART III.

GENERAL OBSERVATIONS.

THE materials for the Second Part having exceeded our expectation, accumulating upon us during the progress of the work, we are under the necessity of confining our general and theoretical remarks within narrow limits. This circumstance many of our readers will not regret, considering that, in the science of geology, facts are much more valuable than theories. Yet we never meant to occupy this department with idle speculations, but to collect together some of the leading facts, appearing in the two former parts, and state some inferences that may be deduced from these facts; at the same time offering such hints, or throwing out such conjectures, as may serve to explain or elucidate the phenomena observed. This we shall now attempt, in a compressed form; arranging our observations under two heads; the one, which we entitle FACTS AND INFERENCES, comprehending what may be regarded as certain; the other, entitled HINTS AND CONJECTURES, comprising what is only probable.—We begin with

FACTS AND INFERENCES.

Some of the propositions introduced under this head are so obvious, as to need little or no illustration: others will require to be

stated and discussed at greater length. For the sake of reference, and for greater perspicuity, we have numbered them.

1. The whole of our rocks (the whinstone dike excepted) have been formed by aqueous deposition.—The parallelism of the beds, the arrangement of the organic remains in seams, and the position of the large and broad shells, skeletons, and pieces of wood, which have their flattest sides placed in the planes of the strata in which they are imbedded, all concur in proving, that the materials of each stratum must have successively floated in water, and subsided to the bottom.—It follows, as a corollary, that all our strata have been covered by the sea, at the time of their formation.

2. Hence it appears, that the strata must have been originally horizontal, or nearly horizontal.—In depositions by water, there is always a tendency to the horizontal posture; and where we see beds that are the result of aqueous deposition running parallel to each other for several miles, we must conclude, that they have been deposited horizontally, or on a declivity so gentle as not to affect their apparent parallelism.

3. Some powerful force, acting upon the strata, has thrown them, in almost all places, out of their horizontal position, and produced extensive dislocations and contorsions.—Into the nature of that force, we do not at present inquire; but its effects are every where visible, in the present irregularities of the strata, described in Part First. No one who attentively observes the breaks and undulations at Whitby, at Peak, at Scarborough, and other parts of the coast, can suppose that the strata were originally deposited in their present form. When we see the aluminous beds gradually descending at Hawsker Bottoms, and after various undulations, suddenly breaking off at Whitby harbour, and then rising again at Sandsend, in the same order in which they had sunk, we are compelled to believe, that they were once continuous, and that their continuity, as well as

their horizontality, must have been disturbed by some mighty agent, elevating the strata in some places, and sinking them in others.

4. Besides the irregularities appearing in breaks and undulations, there are others which have been produced by the washing away, or removal, of large portions of the upper strata.—Examples of such *denudations*, as they are called, occur in every part of the coast. Thus, the strata at Filey Bridge must have been covered with beds of oolite, corresponding with those of Seamer and Ayton; and the strata that break off on the south side of Robin Hood's Bay, must have formerly been connected with the corresponding beds that begin abruptly on the north side; though the interval now presents a blank, down to the lowest shale. Denudations of this kind appear in the interior, as well as on the shore; particularly along the northern and western fronts of all our ranges of hills. We cannot well suppose, that the chalk hills, the oolite hills, or the Cleveland hills, had originally the abrupt faces which they now wear; and no rivers flow round their bases, capable of effecting such a demolition of the upper strata as must have taken place. Similar abrasions appear on the summits and southern slopes of the hills. Thus, the oolite of Pickering, instead of advancing to Saltergate Brow, leaves off abruptly a little to the north of Lockton; and the same phenomenon is common in other parts of the oolite range.

5. The alluvial beds have been deposited after the occurrence of these breaks and denudations.—This is clear from the fact, that the alluvium is observed to fill up the breaks of the strata, and smooth the surface. It adapts itself indeed to the larger undulations of the strata, rising as they rise, and falling as they fall; but it conceals the smaller inequalities, and even very considerable breaks, filling up the hollows and chasms. Thus, the ground between Whitby and Dunsley lane is nearly on a level, except at the ravines of Upgang and Newholm, while the strata beneath repeatedly rise and fall.

The surface gives no clear indication of the bendings of the strata between Whitby and Hawsker Bottoms, or even of the great break at Peak. A few contortions and denudations have indeed occurred in the alluvial beds themselves, as we found on the Holderness coast (see p. 19, and Pl. I); but the contortions and breaks of the regular strata have all, or almost all, preceded the deposition of the alluvium. In fact, the alluvial beds appear to be composed of materials derived from breaks and denudations.

6. Our vales, river courses, bays, and creeks, have been formed chiefly by such breaks and denudations.—Some eminent geological writers have maintained, that the valleys have been formed by the streams which flow in them; that every river has hollowed out its own channel in the hills through which it passes; that bays and inlets on the shore have been excavated by rivers, and by the action of the sea; and that the alluvial beds, even in the highest situations, have been deposited by rivers, that once flowed there. The phenomena which our district exhibits, can by no means be reconciled with such notions. The agency of rivers has indeed had a considerable effect in modifying their channels, but the channels have derived their origin from breaks and denudations of the strata; to which also, the indentations of the coast are principally owing. This is so much the case, that we observe some dislocation of the strata, at almost every bay and inlet on the coast, and at the mouth of almost every stream that runs into the ocean. The Esk did not cut its way into the sea through our rocky cliffs, but its channel was opened by a vast break in the strata, and by the denudation or washing away of the loose materials, disengaged by the shock which this dislocation produced. The river may have filled up some hollows and inequalities of its original channel, but it cannot have excavated those extensive and diversified dales through which it runs. This is obvious, from the circular shape of some of them, as that of Ruswarp; from their general form and

arrangement; and from decisive indications of breaks, elevating the strata on the south side, and sinking those on the north. The numerous dales that open into the vale of the Esk from the south, have originated in an equal number of fractures in the strata, aided by denudations of these strata: and in some instances, as at Fryop, and at Danby, there has been a compound fracture, the dale which is single at its upper end, branching into two before it reaches the Esk, and inclosing between the branches a delta-shaped hill, detached from the principal chain. This phenomenon, together with the steepness of the sides of these dales, and the roundness of their upper extremities, must wholly set aside the idea, that they could be hollowed out by the petty rivulets which meander through their rich alluvial bottoms. As a proof that the Esk has not hollowed out its bed, we may also notice, that a little below Danby castle, it turns aside to the right, out of what appears its direct course in the valley, and passes through Cronkley Gill, in a deep rocky chasm, the margins of which are much higher than the middle of the vale, through which we might have expected the river to flow, and into which it again returns at Lealholm Bridge. Now, if the river had excavated the middle part of the valley, and formerly flowed there, how could it forsake that natural channel, to cut a circuitous passage through rocky strata, the surface of which is considerably higher than the alluvial vale which, on that supposition, it deserted? A similar instance occurs in that small branch of the Esk which flows from Tranmire and Stonegate. A little below Stonegate, the stream bends to the right, and runs in a deep rocky fissure on one side of the alluvial valley; the middle part of which is left dry, though greatly below the level of the banks of the stream, as if artificial means had been used to turn the rivulet out of its natural course. A third instance, fully more remarkable, occurs in the Esk, near where this stream joins it. The river, before arriving at Arncliff, leaves the valley, and seems to make a

sweep through part of a hill. In a similar way, the Derwent, which rises in the moors between Whitby and Scarborough, does not run down to the sea by the opening at Scalby, but passes on between steep banks to Ayton, and into the vale of Pickering; and on approaching the chalk strata, it does not turn to the left in the direction of Filey, which seems the most natural and easy passage, but flows round the foot of the Wolds, by Malton and Howsham, finding its way between banks that are higher and stronger than the obstacles which opposed its progress in the other direction. In such cases, it is quite clear, that the streams have neither cut their channels, nor deposited the alluvium that covers the principal part of the valleys through which they pass. Many of the valleys, indeed, bear marks of their having been formed or modified by the flowing of waters; yet not by the flowing of their own little streams, but by the waters which once covered the whole of our rocks; and which in retiring have washed away vast portions of the more loose or exposed parts of the strata, and employed the materials, thus obtained, in forming the alluvial covering.

In like manner, the river Tees, and its tributary streams, cannot be conceived to have given the fronts of the Cleveland hills their shape, and formed the deep recesses between them. The Leven, which collects a great part of the streams that flow from them, makes its way through deep beds of alluvium, which it cannot have deposited; but though it has deepened its channel, by wearing away the soft alluvial beds, it has made little impression on the sandstone strata, in the few places where it reaches them. To ascribe to currents so limited in their operations, effects of such magnitude as the shaping of mountains, and the formation of extensive valleys and plains, is altogether unphilosophical.

Besides, what shall we say of those valleys in which there are no streams, of which we have so many in our oolite hills and chalk hills? And what shall we say of the subterraneous channels of the becks

that flow into the vale of Pickering? Have these channels also been excavated by the streams? Or how shall we account for another singular fact, that the becks or rivulets which flow southward from the highest range of the alum hills, on arriving at the oolite hills, pass directly through them, instead of turning into the valley that runs along their northern fronts? Had a river run in that valley, all these becks would have fallen into it, and pursued their course with it to the ocean, without breaking through the oolite hills at all; or, at the most, one passage through these hills would have served for the whole. When, therefore, we see each of these becks holding a straight course through an opening in the oolite hills, exactly opposite its channel in the alum hills, there is no way of explaining the phenomenon but by supposing, that both parts of its channel have been formed by the same break in the strata.

Another proof that river courses have been produced by such breaks and denudations, we find in those places where the heads of two opposite valleys run into one; their heads forming a low marsh, from whence the waters flow in contrary directions. Thus, Newton Dale is connected with the vale of Godeland by a narrow marshy vale or hollow, above a mile long, called the *Fen.* This fen, in which the waters are stagnant, has the same kind of high banks as the dales which it unites, and of which it is obviously the continuation. Now, if we could suppose, that the beck of Newton Dale has cut its channel, a supposition highly improbable, the channel being extremely deep, and carried through thick beds of crow-stone and other hard rocks; the question would remain to be solved, What hollowed out the fen? It is clear, that the formation of the fen, and of the dales which it unites, must be attributed to one great break, passing from the vale of Pickering into that of the Esk. An instance of the same kind occurs in the two opposite vales of Commondale and Kildale; which form but one long narrow valley, connecting the vale of the Esk with the

plain of Cleveland. As the whinstone dyke passes through part of this valley, the idea of its being the result of an extensive break is the more confirmed.

In regard to the indentations of the shore, there is no doubt that the sea has greatly modified their shape, but their origin must be ascribed to breaks and denudations of the strata. Wherever bays have been formed on the coast, as at Filey, Robin Hood's Bay, Sandsend, and Runswick, we can trace their formation to breaks, subsidences, or interruptions, of the strata. Even our promontories and cliffs must have been formed by similar means. Vast masses of the strata have sunk down, and become part of the bed of the ocean, while the rocks from which they were detached have remained as sea-cliffs. How can we account for our submarine cliffs and promontories, but by supposing, that the rocks which are below the level of the sea have experienced dislocations, like those above it? Indeed, the form and position of Whitby rock (see p. 159) may suffice to shew, that the breaks in the strata have extended outwards beyond the line of the shore.

7. In several places, the strata, through the effect of subsidence, are disposed in the shape of a basin.—Some instances of this kind have been noticed in Part First, particularly the chalk strata, and most of all, the oolite strata. The vale of Pickering is like a vast basin, the central part being sunk or depressed, while the oolite strata dip towards it all around, except where it is bounded by the chalk. Many writers speak as if the basin form were almost peculiar to coal strata, but any other strata must assume this form, where the middle part of a district, or extensive mass of strata, has sunk down, while the outer parts slope towards it on every side. The coal beds of our district are perhaps the least thrown into that shape of any of our strata; though even in them we find here and there small round depressions, or basins, of which the circular vale of Ruswarp has been

noticed as an example*. In many instances, through a fondness for generalizing, or an attachment to theory, authors have bestowed the name *coal basin* where it is by no means appropriate. Thus, we read of "the coal basin of Newcastle", or "the coal basin of the Tyne and the Wear," though the coal strata of that district are no more in the form of a basin, than the metalliferous limestone on which they are understood to repose, or than the magnesian limestone which reposes over them: for if the coal measures lie in the bosom of the metalliferous limestone, the magnesian limestone lies in the bosom of the coal strata. Nay, we may say further, that the red sandstone lies in the bosom of the magnesian limestone, and the aluminous series in the bosom of the red sandstone; and that each of the remaining members of our strata seems to embrace that which precedes it, extending round it, and under it, in a form more or less curved. Indeed, we know of no district where the strata are disposed in rectilineal planes, without any degree of curvature.

8. Many of the strata are found to *wedge out*, or run to a thin edge; and this may have been the case with all the strata.—We have ascertained, that there are beds in the interior which do not make their appearance on the shore, and beds on the shore which are not found in the interior; and that, in not a few instances, strata of great thickness, grow thinner and thinner, till they wholly disappear. Not to speak of the seams of ironstone and coal, we find great beds of shale, of crow-stone and other sandstones, and even of oolite, thus wedging out; for to the south of Malton and of Castle Howard, we find the whole oolite

* Since the two preceding Parts of our Work were printed, we have seen a Paper by N. J. Winch, Esq., entitled "Observations on the Eastern part of Yorkshire," published in the Fifth Volume of the Geological Transactions. In that Paper, Mr. Winch states, that the coal formation which covers the alum shale *forms a basin*. Had that gentleman examined our district himself, instead of attempting to describe it from scraps of information collected from others, he might have avoided that mistake, as well as several other errors into which he has fallen.

series reduced within a small compass, and ready to vanish. Analogy would therefore lead us to think, that each stratum may have originally been a kind of flat lenticular mass, wearing to a thin edge on every side. It has been justly observed by some authors, that the crust of our globe is rather to be described as squamose, like an artichoke or the root of a lily, than tunicate, with concentric coatings, like an onion. The notion of *universal formations*, or of rocks of any one kind that have completely enveloped the globe, is not borne out by the facts before us. Some of our strata may indeed be traced in certain directions to a great extent; particularly the chalk, the oolite, and the aluminous strata with their lias seams: but as we find them all wedging out on some of their sides, and other strata doing the same on all sides, we may reasonably presume, that these more extensive masses, if traced out, would be found to terminate in a similar way. The chalk strata reach, with some interruptions, from Flamborough Head, to the south of England; and are found to extend into France, and other parts of Europe; but though we should suppose the whole to have once formed a continuous mass, which is by no means certain, it does not follow, that these strata once encircled the whole globe. It is true, that the strata of our chalk hills, and those also of the oolite and alum hills, leave off so abruptly on some of their northern and western fronts, as to make it evident that they must have extended much further to the north and the west: yet we have no right to infer, that all or any of them have ever reached the Pentland Firth, or the Hebrides. The magnesian limestone may have stretched much further than it now does, over the coal measures of Durham and perhaps of Northumberland; the red sandstone, if it be not a mere *upfilling*, may have extended a great way over the magnesian limestone; the aluminous beds and lias seams may have reached far over the red sandstone; and each of the succeeding members of the series might spread out in a similar way; but each of them, we may presume,

successively terminated in a thin edge. During the convulsions which threw the strata into their present form, these thin edges, being the most vulnerable parts of the strata, would be most liable to be shattered to pieces and washed away; especially where the softer strata, such as the chalk, the shales, and the red marl, were thus exposed. Accordingly, the greatest denudations have taken place, behind the chalk and the upper shale, in the south part of our district; and in the region of the alum shale and the red marl, in the north part.

9. Hence it appears, that we are not to expect in other parts of Britain, the same series of strata as are found in our district; much less can we presume, that the same series may be traced round the globe.—Attempts have been made, to arrange all the beds composing the crust of our globe into a complete series, exhibiting the order in which, with a few variations, the strata have been deposited, and may be expected to occur. Such attempts, however, have failed in establishing any precise order observed by the strata; they have only succeeded in tracing, in many instances, a considerable analogy, between the series occurring in different places. From the extent of the chalk, the oolite, and a few other rocks, we may infer, that the deposition of these strata has taken place on a grand scale; but neither these, nor the strata associated with them, have been deposited according to fixed laws, in respect of extent, succession, or relative position. One stratum wedges out in one place, and another in another; and the series rarely continues the same to the extent of fifty or sixty miles. Could we penetrate the strata at Whitby, so as to ascertain what rocks are under the aluminous beds, it is by no means certain, that we should fall in with the series of Durham and Northumberland; and we know, that some important members of our series have not been met with beyond the Humber; as, on the other hand, beds that lie under the chalk in the south of England, have no place here. No beds have hitherto been discovered in any other district, corresponding

with our coal measures. They bear a strong resemblance, though on a smaller scale, to the coal strata of the Tyne and the Wear; but to such as plead for a regular succession in the strata, they must appear quite out of place; nothing of the kind being found elsewhere above the lias or aluminous beds; unless the bituminous shale called *Kimeridge coal* be deemed an approximation to our coal strata. On the other hand, we find nothing here corresponding with the *green sand formation* of the southern counties. Some have fancied, that they discovered it in the Filey rocks, where several of the petrifactions have a greenish hue: but there it would be out of place, these rocks being inferior to the oolite. The difficulty of establishing any settled order, or complete series, appears very striking, on a comparison of our strata with those of Lincolnshire. In that county, red chalk succeeds the white chalk, as at Speeton; but among the beds beneath it, we look in vain for any correspondence with our rocks: the strata are so changed, that we can scarcely identify one member of the series. The red chalk is neither followed by green sand, nor by shale; but by a considerable bed of coarse brown sand; under which is a bed of calcareous clay, twelve or fourteen yards thick, containing oolite, partly in seams, and partly in masses or nodules. Into this small compass are the vast strata of our oolite hills here reduced. Beneath this, occur sandstone strata of a greater thickness, containing marine shells; and these are succeeded by a series of beds, bearing some analogy to our aluminous strata; consisting of several varieties of shale, some of them highly bituminous, parted by hard seams of different descriptions, among which are a few bands of ironstone; the whole shewing a mixture of pyrites, and of calcareous matter. This series has been penetrated to the depth of an hundred yards.* It is difficult to say, whether it corresponds with our second shale, or with our aluminous strata.

* Geological Transactions, III. p. 394, &c,

It may be proper to notice, however, that some of the strata, after being discontinued, are found, in several instances, to resume their stations. Thus, the upper shale, which is wanting in Lincolnshire, reappears in the *gault* of Cambridgeshire, and perhaps in the *blue marl* of Folkstone, which is continued on the opposite coast of France.* Yet our upper shale, as was formerly observed (p. 60), is so like the *London clay*, that had it occurred above the chalk, it would doubtless have received that appellation. Indeed, as the green sand is found under the chalk in some places, and above it in others,† the position of the clay may admit of the same variation.

In some parts of Somersetshire and Dorsetshire, the chalk comes in contact with the red sandstone, all the intervening strata having disappeared; but in other parts of that district, the series bears a considerable analogy to ours; there being an upper shale (termed *Oak-tree clay*), some oolite and sandstone strata, aluminous or lias strata, and red sandstone. It would seem also, that our second shale occurs in some spots, under the designation of *clunch clay*. There are, however, few places where this analogy is distinctly seen; and when we attempt to trace it out of Britain, and especially out of Europe, we soon find ourselves completely lost.

10. Some parts of the strata are so nearly allied, that they often pass into one another, and occupy the same beds.—This observation applies particularly to sandstone and sandy shale, to coal and bituminous shale; and, we may add, to oolite and grey limestone; which, as we have observed (p. 270), pass into one another, at Kirkdale and other places.—Here it may be also remarked, that in other respects, the qualities of beds are liable to great changes and transitions. The dogger is perhaps the most variable of all our rocks; but

* Geological Transactions, III. p. 343; V. p. 37, 49.

† Greenough's Geology, p. 255. This Work contains a most valuable collection of facts, many of which serve to illustrate and confirm our statements.

even the blue limestone, which is one of the most constant, undergoes a material change towards Sutton and Coxwold. These variations in the nature of beds increase the difficulty of tracing the connections of the strata.

11. Some portions of the strata are subordinate to others; and some seams, or inclosed masses, appear to be secretions from the beds that contain them.—Among the rocky substances of this subordinate rank, we may notice the following; flint, in the chalk; chert, in the oolite; the rounded nodules or balls, in the calcareous sandstone; ironstone nodules, veins, and seams, in different kinds of shale, and of sandstone; lias and pyritous septaria and nodules, in the upper shale; the same nodules, and the lias seams, in the alum shale; and blue and green seams, with gypsum veins, in the red marl. All these substances, which do not form separate beds by themselves, but are included in other members of the strata, are to be regarded as subordinate to the beds which contain them; and most, if not all of them, appear to be secretions from these beds. The process of secretion, however, is by no means of a recent date; as is the case, in some instances, with the formation of calc spar in crevices of the strata, and selenite in shale; but must have taken place about the time when the strata were deposited, or before they were fully indurated. The appearance of the flat nodules, and imperfect seams, of flint, of ironstone, and even of lias, strongly impresses us with the idea, that these substances were originally diffused through the mass of the strata to which they respectively belong; and trickling downwards, were collected into the horizontal seams of the strata, spreading themselves according as they could find room to collect or expand, and accommodating their forms to the vacancies, or softer spaces, into which they insinuated themselves. Thus, the nodules and seams of ironstone are most abundant towards the lower part of the shale beds containing them; and where a bed of sandstone closes

the series, the ironstone forms a crust over it, as if it had subsided to the bottom. Any hard seam, either in the chalk, the shale, or other principal beds, would suffice to cut off the communication with the beds below; and this accounts for our finding the secretions stopping at different stages, instead of descending wholly to the bottom. Even where the seams of nodules form nearly continuous beds, as is the case with the flint, the ironstone, and the lias seams, they may still have been secretions from the beds in which they run. The notion which some authors have adopted, that these substances, particularly flint, may have been forcibly injected from below into the principal beds, like melted lead, is utterly irreconcilable with the phenomena presented. Where are the openings through which the fused substance was forced? Why has none of it stuck in the strata which it pierced? Or how could it assume, in the case supposed, the form which it now wears! We may, indeed, feel a difficulty in conceiving, how such secretions could take place; but it is as difficult to conceive, how the consolidation of the strata was produced. If chemical agents effected the one, might they not also accomplish the other?—This leads us to remark,

12. The members of the strata are in very different states of induration, and as the difference is not according to the order of succession, it must be owing to a difference in their intrinsic qualities, and in the circumstances of their deposition, rather than to any extraneous cause.—We have seen, that some of the strata are remarkably soft, while others are extremely hard. Some of the calcareous beds consist of loose marl, others are highly crystalline, approaching to marble; some of the sandstones are very friable, and nearly in the state of sand, while the crow-stone beds are hard and compact, like quartz rock; and some of the shales are soft, like clay, others are hard and splintery. We have observed a similar difference in our organic remains, some being merely preserved, others in various states of

petrifaction; and even among our ironstones, or ferruginous balls, we have found some in the state of soft ochre, while others are in a hard metallic form. It is not easy to investigate the causes of these different degrees of induration; but we may safely state, that they have not originated in any extrinsic agency, operating either from below or from above. Had the consolidation proceeded from below, we should have found the hardest beds lowest; had it proceeded from above, the order must have been reversed; but as we find the hard and soft strata alternating, without observing any such gradation, we must look for the reason of this diversity in the original qualities of the substances composing the strata, their chemical affinities and attractions, or similar causes operating about the era of their deposition. The structure of some of the beds might be influenced by those immediately over them; for we have noticed (p. 115), that the blue limestone appears to have sent down a large portion of calcareous matter into the sandstone that succeeds it. Some time may have been requisite to complete the consolidation of the hard beds; but time alone has not effected the change; for the softer strata cannot be inferior in age to the compact beds with which they alternate.

13. Our strata cannot have been formed at the bottom of a former ocean, in the same gradual way in which the earthy sediment, brought down by the rivers or detached from the shore, is now deposited in the bottom of the sea.—It is the opinion of many geologists, that our present strata have resulted from the gradual demolition of more ancient strata, the materials of which, being washed away by the rains and streams, were deposited in the bottom of an ancient ocean; and that, through the effect of a supposed central fire or heat, in the interior of the globe, they were consolidated, and then raised up to form our present dry land. Such authors assert, that the same process is now going forward; the spoils of our present strata, carried down by rivers, or detached from the shore, being deposited in

the bed of the ocean; from whence, at a future era, they will rise in a stratified form, constituting new continents and islands. Against these notions, a host of objections might be started; but it is sufficient to remark, that the peculiar character and vast thickness of some of our strata, particularly the chalk and the oolite, preclude the possibility of their having been formed by such a process. The sea receives from the waste of the land, quantities of mud, sand, gravel, &c.; which it deposits in thin layers, partly on its shores, and partly in the deeper parts of its bed; but these thin layers bear no proportion to the massive strata of our rocks. To produce such a series of strata as exists in our district, in the way supposed, a long succession of ages would be requisite; and, during some of these ages, the rivers behoved to send into the sea nothing but sand; during others, nothing but mud or clay; during others, nothing but materials for oolite; and during others, nothing but chalky matter. One of the most learned of the authors alluded to, has stated, that it would require at least a century, to waste away the surface of the land to the depth of one foot, and deposit it in the bottom of the ocean.* Now, if we estimate the chalk strata at three hundred feet in thickness, it would require, at this rate, *thirty thousand years, to form the chalk strata only;* even supposing the ancient sea to be of no greater extent than the dry land: and during this immense period, the rivers behoved to convey into the ocean, where these beds were forming, nothing but materials for chalk and flint!!! It is clear, that our strata must have been produced by very different means, and deposited on a far grander scale.

14. Some of the strata abound with organic remains, others contain few or none; and this diversity is not according to the order of their succession.—The beds that contain most organic remains, viz. the oolite and the alum shale, are neither the highest nor the

* Playfair's Illustrations, p. 424, Note.

lowest; and there are beds between them, particularly sandstone and sandy shale, containing almost none. In general, the siliceous strata contain the fewest, and the calcareous and argillaceous the most; yet in the red sandstone, which is both calcareous and argillaceous, we have found none. There is no doubt, that quantities of animal and vegetable matter, originally imbedded in the strata, have been entirely dissolved, as we find only the harder substances remaining; and these too in various states of preservation, according to the quality of their matrix.

15. The organic remains, in some of the strata, consist wholly or chiefly of marine productions; and in others, of land productions; while in most, there is a mixture of both: nor is there any thing in our strata, that favours the hypothesis of an alternation of fresh-water and marine formations.—The petrifactions discovered in the coal and the bituminous shale, in the siliceous sandstones and some of the sandy shales, have been derived from the land; consisting of wood, and other vegetable substances; in other strata, as in the blue limestone, we have seen only marine shells: but most beds abounding with organic remains, display a promiscuous assemblage of petrifactions of both sorts. The most natural inference to be drawn from these appearances is, that when the strata were deposited, the productions of the sea and the land were blended together; and that, as might be expected, they were lodged in the different strata in various proportions; some beds containing most of the one kind, some most of the other, some both, and some neither. Some French authors, however, to whom science is otherwise much indebted, having discovered among the strata over the chalk near Paris, some beds containing what appeared to be fresh-water shells, alternating with others containing marine productions, have accounted for this phenomenon, by supposing, that such spots have been alternately overwhelmed by the sea, and by a fresh-water lake; a notion which has

been imported into England, and zealously patronized. But, how could this alternate submersion of the strata, in salt water and fresh, take place, without destroying their conformity? Convulsions of such magnitude as to expel the sea, and introduce a fresh-water lake, and again destroy the lake, and restore the sea, could not have occurred, without violently agitating and breaking the strata, so that there could be no conformity or parallelism between beds thus deposited. Is it possible, that, after depositing the alum shale and the dogger, the sea, in this quarter, gave way to a mighty lake, which formed our coal strata; that this lake was, in its turn, expelled, the sea returning to form the blue limestone; that the fresh-water again prevailed, but after leaving the crow-stone beds as monuments of its prowess, finally quitted the field, allowing old ocean to resume his pristine sway;—and that, during this dreadful struggle for the ascendancy, the operations of both agents proceeded in unison, so as to leave no vestiges of the direful contest, not a trace of such mighty revolutions? Some of the methods employed by the authors of this hypothesis to bolster it up, betray a disposition to set up theory against fact. In one of their supposed fresh-water formations, *marine* shells of the genus *cerithium* were discovered. What then? Must the hypothesis be abandoned? By no means:—the sea-faring straggler, being found in such company, is to be deemed a *landsman*, a new fresh-water shell, and is therefore dubbed a *potamides!** We wonder that its presence was not rather imputed to the pranks of some mischievous sea-gulls, who might amuse themselves in picking up shells from the sea shore, and dropping them in the fresh-water lake! There is reason to suspect, that a great number of the supposed fresh-water shells of these authors, are in reality marine shells; it being difficult, in many cases, to distinguish between them.†

* Geological Transactions, II. p. 230, Note.

† It appears from the experiments of M. Beudant, that some fresh-water shells may live in salt water, and vice versâ. See Philosophical Magazine, Vol. XLVIII. p. 223.

16. Of the organic bodies imbedded in our strata, some are in a high state of preservation, others are greatly mutilated, compressed, or otherwise injured; and we have no evidence to prove, that any of them ever lived on the spots where they are found.—It is contended by not a few authors, that a great part of the animals and vegetables which we find petrified, formerly lived where they are now imbedded; because they are found in a high state of preservation, and some of them, especially shell-fish, are found lying in that regular order which we may suppose them to have had when alive. But appearances of this kind, though not uncommon in our district, are not sufficient to determine the point. The most remarkable instance of the regular disposition of organic bodies in our strata, is that of the petrified reeds near High Whitby, mentioned p. 184. Most of these reeds stand erect, as if they had grown on the spot, with their roots in the clay that is below their sandy matrix. It is most probable, that they did grow in the clay; yet, may we not suppose, that the clay, with the reeds in it, might be floated hither, at the formation of the beds, accompanied with the sand, which lodging among the reeds, became their matrix? This idea is corroborated by two circumstances; one of which is, the total absence of the upper part of the stalks, which all terminate at the surface of the sandstone bed, as if they had been broken off; and the other is, that their roots are almost all bent, and bent in one direction, as if they had been dragged along from some distance. The orderly position of some beds of shells may be accounted for in a similar way; or it might be effected by the regularity of the successive waves that deposited the strata with their contents.—Nor is the high state of preservation, in which many of the shells are found, a proof that they have not suffered transportation. The most delicate shells might float round the globe without being injured, provided they were entangled in any mucilaginous, clayey, or soft matter, that might serve to defend them; and we have

great reason to believe, that the *nuclei* of many of our lias and iron-stone nodules, which contain the best preserved petrifactions, originally consisted of such matter. Besides, when we find in the same bed, shells that are well preserved, associated with others that have been violently broken, distorted, or mutilated, what can we think, but that incidental circumstances have preserved the former, from the violence that injured the latter? It is well known, that very entire shells are found even in gravel beds, where they might be expected to be broken or water-worn.

After all, what can be meant by the assertion, that the shell-fish have lived and died on the spot? Can it mean, in regard to such beds as our alum shale or oolite, that the animals imbedded actually lived in the clay or calcareous matter? That is physically impossible. *Pholades*, or similar shell-fish, might burrow in beds of clay or marl; but that is not the state in which our petrified shells are found, and we rarely meet with shells of that description. The stone in which the *mytilus lithophagus* occurs, is very different from the oolite in which it is found, and may be presumed to have been transported from a distance. Does the assertion mean, that the shell-fish lived on the surface of the stratum below, and were covered by the deposition of the clay or calcareous matter over them? Had that been the case, we should have found the mass of shells at the bottom of the beds that overwhelmed them. Does it mean, that the animals lived on the surface of these beds, and were covered up by the succeeding beds? Then we should have seen them all in the upper part of the clay or oolite. Or, does it mean, that these beds, particularly the limestone beds, were formed by the calcareous matter resulting from the decay of successive generations of shells? In that case, we ought to find the entire shells only in the upper part of the beds, and the lower parts should consist of nothing but lime, or of finely comminuted particles of shells; whereas we see the shells and

the fragments promiscuously dispersed in the beds; and in some parts of the oolite, near the surface, we find neither shells nor fragments.—In short, the idea that the animals have lived and died on the spot, cannot be reconciled with the phenomena presented; which rather indicate, that the shells have by some means been entangled in, and mixed with, the clay, the marl, or whatever other substance has formed their matrix, and floating along with it, while it was carried in a semidiluted state, have thus been deposited where we now find them.

17. Though some organized bodies are found only, or chiefly, in certain beds, yet, on the whole, the organic remains are so much dispersed and intermixed, that the attempt to identify the several strata by their respective fossils, must be confined within narrow limits.—As attempts have been made to arrange all the strata into a regular series, so it has also been attempted, to assign to each member its proper fossils, on the supposition that we may distinguish each stratum by its organic remains. The latter idea, like the former, may be admitted to a certain extent, but the arrangement is far from possessing that universality and certainty which some suppose. We find some organized fossils in the lowest shale only, some in the compact shale only, some in the main alum shale only, some in the oolite only, and so of the rest of our strata containing such fossils; and it is well known, that several corresponding fossils have been found in strata analogous to ours in other parts of England. Where there is a correspondence between the strata, it is natural to expect some agreement between the fossils imbedded in them; and this idea may assist us in tracing their correspondence. Yet the assistance thus furnished must be very limited; for if some fossils appear peculiar to certain beds, there are others very extensively diffused; and how can we be sure, that such as we deem peculiar to the beds which they occupy, may not be discovered, like their companions, in other beds of a very different description? Most of the shells in the dogger correspond exactly

with shells that occur in the oolite; nay, some of the same species of belemnites and ostracites are found in the lowest shale at Boulby, and in the upper shale at Speeton. Indeed, belemnites and oysters occur in almost all the strata containing shells. The *ichthyosaurus* has been thought peculiar to the alum shale; but we now observe, as we might have done before, that it occurs also in the second shale, at Malton, immediately below the oolite; some large vertebræ of that animal having been dug up there a few years ago. Nay, it would seem, that animals of this family occur in the oolite, the chalk, and even the mountain limestone.* Some fossils, as the tubular belemnites, are found only in certain spots; and we might as well pronounce them peculiar to the spots, as peculiar to the strata. Besides, there is scarcely more difference between the fossils of different strata, than between those of the same stratum in different places. In the fronts of the Cleveland hills near Guisborough and Stokesley, we find in the alum shale, no specimens of *ichthyosaurus*, of pike, of *arca rostrata*, &c.; but we meet with several shells not hitherto observed on the shore. In like manner, some of the oolite fossils that occur at Malton are not seen at Pickering, and *vice versâ;* there being several shells in the oolite strata, found only in particular spots. We may add, that our strata contain organic remains not known to exist in the strata analogous to them in the south of England; and many fossils occur there, which have not been observed here.

18. Of our fossil organized substances, some correspond with recent animals and vegetables, others have no recent analogues hitherto known; and these two classes are so intermixed, that we cannot regard the latter as more ancient than the former.—It is a fashionable opinion among geologists, that the animals and vegetables imbedded

* Geological Transactions, V. p. 591, 592.

in rocks, are more or less ancient, and differ more or less from the present animals and vegetables, according as they are lower or higher in the series of strata. Such authors speak of different races being successively created and destroyed; each succeeding race approaching nearer to the present genera and species. According to them, there was first a world of zoophytes; and this being destroyed was followed by a world of cockles, or such like bivalves; which cockle world being also ruined, was succeeded by a world of crocodiles or huge lizards, destined to perish in their turn, to make way for other creations; a few stragglers from each lower world being allowed, however, to ascend and hold a station in the world next above: but all the inhabitants of these numerous worlds became extinct, before the creation of man, and his present fellow-tenants of the globe. Some go so far as to assert, that not one fossil species agrees exactly with any living species; except a few species found in the alluvium, which by peculiar favour have obtained a kind of *apotheosis,* having ascended from the world last destroyed, to figure in the present.—These notions, which seem to have gained currency chiefly through their novelty and their wildness, it is impossible to reconcile with facts. No such gradation exists; but we see in all the beds, whether high or low, organized substances that have recent analogues, and others that have not; and find as large a proportion of the latter in the oolite and the chalk, as in the aluminous strata. Zoophytes abound most in the chalk and the oolite, while in the lowest shale we see oysters and other shells, corresponding in every respect with living species. Indeed, there are some shells, particularly ostracites, ammonites, and belemnites, that exist in almost all the strata containing organic remains. They occur in the chalk and the oolite, and in the lowest shale: nay, they occur in much *lower,* or to use the common phrase, *older* strata; for Dr. Macculloch discovered belemnites in Garvh island, in limestone alternating with

gneiss and quartz rock.* The idea, that none of our fossil animals or vegetables can be assigned to any recent species, cannot be admitted, without shutting our eyes against the clearest evidence; and several genera and species now regarded as extinct, may yet be found recent. Many countries, rivers, and creeks, remain to be explored; and doubtless the ocean contains living treasures hitherto unseen. Brown in his travels in Egypt, &c. (p. 70), observes, that, with the exception of some eels, none of the fishes which he found in the Nile correspond with the European fishes: and every scientific traveller discovers in distant parts of the world, new species, and even new genera, of animals and plants. Within these few years, the *trigonia*, which was deemed an extinct genus, has been found recent; and the same remark is applicable to a few other genera. After the recent accessions which natural history has acquired, particularly the discovery of the ornithorhynchus and of the animal of Stronsay, we need not despair of seeing the lizard-fish in a living state.

The authors of the hypothesis of successive creations, or *formations*, as they are more frequently termed, have not told us, what we are to make of the extensive strata containing no organic remains, or next to none, intervening between strata that abound with them. Was the creative power suspended or contracted for some ages? Did worlds of barren sand alternate with worlds replete with life?

We have other objections to produce against this theory, but they will appear with more advantage under the next observation.

19. We have reason to believe, from the facts before us, that no considerable interval occurred between the deposition of the several

* Description of the Western Islands, II. p. 512. It is worthy of notice, that Dr. M. observed in Rasay and Sky, a series of strata, reposing on graywacké schist, conglomerate, and gneiss, bearing a strong analogy to part of our strata; consisting of white sandstone, dark blue shale with thin seams of coarse limestone, and below that, red sandstone. The shale contains ammonites, ostracites, gryphites, belemnites, &c. Ibid. I. p. 250, &c.

members of our strata; but that they were all deposited nearly about the same period.—The doctrine of successive formations is connected with the opinion, that ages intervened between one formation and another; and that the lowest strata are of very high antiquity, while the upper strata, such as the chalk beds, are comparatively quite modern. To the same system belong the notions, which we have already exploded, that the animals petrified in the several formations are peculiar to these formations, and that they have lived and died on the spots where we find them.

As the formation system has many learned and zealous advocates, it is the more necessary to set forth the leading facts, from which we draw the conclusion, That the different members of our strata have been all deposited nearly about the same period.

(1.) The breaks in the strata are not limited by the boundaries of any particular member of the series, but affect the whole mass of the strata at the places where they occur. Had the strata been deposited in successive formations, separated by ages, or long periods of time, we ought to find in the lower formations their own peculiar breaks and irregularities; and might expect to see, in numerous instances, breaks leaving off at the limits of the several formations; and to observe the materials of the higher formations descending into the fissures of the lower. Now, when we perceive, on the contrary, the same breaks passing directly through the aluminous beds, the coal measures, the oolite, and all the intermediate strata, without any regard to supposed formations, it is natural to conclude, that the division of the strata into such formations is the work of fancy. We do not, indeed, find any one break crossing the whole series; but we see a succession of breaks connecting the different members, and shewing the whole to be, not a series of formations, but one grand formation.—The effects of the denudations of the strata lead to the same conclusion; for the chalk, the upper

shale, and the oolite, have been swept away together between Speeton and Filey; and the aluminous beds and red sandstone have been involved in the same destruction towards the Tees.

(2) Most of the breaks or dislocations have taken place when the strata were but half consolidated; so hard as to break, yet so soft as also to bend. This fact deserves particular notice, as being, in our opinion, the most decisive evidence of the point in dispute; especially when viewed in connection with the fact last stated, and with the remarks made above (§ 12) on the induration of the strata. Had the strata been of different ages, we should have found at the breaks that pass through several members of the series, indications of the greater hardness of the lower beds, and softness of the upper, at the time when these breaks occurred. But, instead of this, we see in the bends, undulations, and contortions, accompanying the breaks, indubitable proofs, that the beds which are now the hardest were capable of being bent at the era of these dislocations, and the lowest as much as the highest. The undulations in the ironstone and hard sandstone on both sides of Scarborough; those in the sandstone at Haiburn wyke; those in the hard bands of the aluminous strata at Peak and Robin Hood's Bay; and those in the dogger near Saltwick, on the east side of Whitby harbour, and in the sandstone on the west side, may be quoted as examples. They shew, that as the great breaks on the coast run through the entire mass of the strata, wherever they occur, so they must have taken place when every part of the mass was somewhat flexible. In some instances, indeed, the curvature of a bed is partly owing to small cracks or rents; but independent of such cracks, there is a real bending of the mass of the stratum.—Even the denudations present appearances, indicating that they must have occurred when the strata were but half consolidated; for it is difficult to explain, on any other principle, the extent to which the hard strata have thus been demolished.—These facts it is impossible to reconcile with the formation system.

(3) The conformity and close succession of the strata, viewed in connection with their contents, also furnish insurmountable difficulties in the way of the system.—The members of the strata succeed each other so closely, and with so little appearance of interruptions, or long intervals, between their deposition, that the abettors of this theory must find it difficult, if not impossible, to determine where one formation ends, and another begins. The members of the series often run into one another. The chalk might be deemed one of the most distinct formations; and yet we have seen (p. 58) that at its junction with the upper shale, there is a gradual transition of the one into the other, the clay growing chalky, and the chalk clayey. Similar appearances occur at the junction of other members of the series; and even where there is a distinct line of separation, the evenness of that line is a proof, that the inferior member has not lain so long uncovered by its successor, as to allow the hand of time, or accidental causes, to produce inequalities in its surface.—Besides, the contents of the strata do not accord with the formation system. If each member of the series was formed so leisurely, and if its animals expired on the spots which they occupy, why are almost all the larger petrifactions, particularly the large marine animals, so mangled and broken; often parted into a thousand pieces, and their fragments scattered in all directions?—Again, if the strata were formed in the way supposed, why do we find in so many of them, both low and high, masses or fragments of petrified wood? Why is there wood in the alum shale, the ironstone, and the oolite, as well as in the coal and sandstone strata? Had each world its own trees, as well as its own animals? Where are the soils in which the successive races of vegetables grew? And why are the plants and the shells, the trees and the fishes, of these numerous creations, blended together?—On the whole, the formation system may please the imagination, and give scope to the fancy, but it will not stand the test of an appeal to facts.

20. The basaltic dyke bears such strong marks of having been composed of fused matter, thrust upwards through a fissure in the strata, by volcanic agency, or something akin to it, that we may reasonably presume, that such agency may have been employed in raising the strata, out of the ocean in which they were deposited. —Some may think, that we should have placed this observation among our *conjectures*, rather than among *facts* and *inferences:* but the appearances of igneous origin presented by our whinstone dyke, and other similar dykes, are so strong, as nearly to reduce the matter to absolute certainty.* Had the fissure occupied by the whin dyke been filled from above, as some suppose, whence were the materials derived? There are no strata above capable of filling it; and if we could suppose that all the higher members of the series once extended over the space through which the dyke runs, which of these strata could supply the requisite materials? Why are the numerous cracks and fissures, in the oolite and other strata, not filled with the same substance? And, since so many of the upper beds consist of limestone, why does the dyke contain so small a portion of calcareous matter? If the fissure was filled from above, by secretions from beds that have been washed away; why does it not every where reach the surface? Or rather, as it is harder than the strata washed away from it, why does it not every where stand up above the surface like a wall, as it does at Langbargh and some other places? Besides, why are its contents disposed in large oblong blocks, lying

* The Rev. A. Sedgwick, Woodwardian Professor, Trinity College, Cambridge, examined the rocks of this coast a few months ago, and having paid particular attention to our basaltic dyke, and to some trap dykes near Newcastle, and in High Teesdale, was fully convinced, that the evidence for their igneous origin appears quite complete. Near Caldron Snout, he found the limestone, where it comes in contact with the trap, converted into a granular mass, in which you lose all trace of organic remains; but gradually recovering its usual texture at the distance of a few feet. The coal shale, under the same circumstances, is so indurated as to resemble a piece of Lydian stone.

across the fissure; and not rather arranged in a stratified form, or suspended in stalactitic masses? Above all, why is the dyke throughout its whole length composed of crystallized matter, and that matter not at all affected by the nature of the various strata through which it passes? In its progress from Maybecks to Cockfield, it crosses the blue limestone and the sandstone strata above it, the coal measures of our hills, the aluminous strata, the red sandstone of Cleveland, the magnesian limestone, and the Durham coal measures, arriving at, or approaching, the metalliferous limestone; yet the diversified nature of the beds through which it runs has no effect on it. Now, as the substance and structure of the dyke are nearly uniform, and have no connection with the nature or composition of the beds which it traverses, we are compelled to think, that it is all derived from one common source, and that source not above but below. And when we also see along its course, effects produced by it, exactly corresponding with the effects of ignited matter, what are we to believe, but that its substance has been forced upwards in a state of igneous fusion?—Hence, as we have seen that this dyke is connected with slips or breaks of the strata, it is natural to conclude, that the same kind of agency which forced up ignited matter into fissures of the strata, may have been employed in raising the strata themselves, out of the ocean in which they were formed.

We might have drawn another argument against the formation system, from the manner in which the basaltic dyke crosses so many members of the series of strata; but it is high time to proceed to the next and last division of our subject, which we denominate

HINTS AND CONJECTURES.

From the foregoing statement of facts, and chain of reasonings from facts observed, we have arrived at some important results, with

regard to the nature of our rocks, and the circumstances of their formation. We have found, that the strata have been deposited by water, and were originally nearly horizontal; that through some powerful agency, they have suffered great changes, in numerous breaks and denudations, by which valleys and water-courses have been formed; that the different beds are not continued round the globe, nor over all Britain, but wear out successively to thin edges, so that we cannot arrange them into any regular or constant series; that some beds, or portions of the strata, pass into others, and some are secretions from others; that the strata have not been formed by the gradual deposition of sediment, such as is now deposited in the bottom of the ocean; that the difference between the strata, in point of hardness, and in the nature and quantity of their organic remains, is not according to the order of their succession; that they have not been produced by alternate depositions from salt water and fresh, nor by successive creations, or formations, separated by ages or long intervals, and distinguished by peculiar animals or vegetables, but appear to have been formed nearly about the same period; and that volcanic agency, having produced the whinstone dykes, may have been employed in raising the strata, and may have caused some of the breaks in them.—It now remains to be inquired, at what period, and in what manner, the strata may have been deposited.

It is a fashionable opinion among geologists, that all the strata, including even a great part of the alluvial beds, were deposited before the creation of man; and some of the most respectable geological writers have attempted to reconcile the formation system with the Mosaic account of the creation, by supposing that the six *days* of the creation are six *indefinite periods,* of great length, corresponding with the eras of the different formations. Such writers fancy, that they have discovered a coincidence between the order in which organized bodies occur in the strata, and the order of the creation of vegetables

and animals, as recorded by Moses. Our readers must have seen, from the statements given above, that we have observed no such coincidence; and as the notions just mentioned cannot be reconciled with facts, it is equally impossible, in our opinion, to reconcile them with the sacred scriptures.

The very attempt to extend the period of the creation to an indefinite length, looks like detracting from the honours of the Almighty, whose power, instead of requiring six ages for the work, could easily have accomplished it in six hours. The instantaneous execution of the several parts of the work, is represented as an important accession to its grandeur: "He spake, and it was done: He commanded, and it stood fast." Independent of this, the formation system cannot be made to agree with the narrative of Moses. He describes the work of each day, and then represents the Creator as thus reviewing the whole, at the close of the sixth day: "And God saw every thing that he had made, and behold, it was very good." With what propriety could these words have been used, if the work of some of the preceding days had been destroyed, before the sixth day began? Besides, each of the days is stated to consist of "morning and evening;" language which could not, without the most violent straining, be applied to the formation periods. It is true, that the terms *day*, *morning*, and *evening*, are often in scripture, as in other writings, used in a metaphorical sense; but it is contrary to the rules of sound criticism, to understand them in this sense, in the simple narrative of the work of creation. The mention that is made of the *seventh* day, seems to put the matter beyond a doubt. God rested from his work on the seventh day, which was therefore consecrated to be the sabbath; and man was directed, after the example of God, to labour six days of the week, and rest on the seventh. Now, that this may be a suitable motive with us, to devote a seventh part of our time to sacred rest, we must understand, that the six days of the creation and the sabbath

succeeding, occupied no more than the space of a week; or at least, that the seventh day was of the same length with each of the six. If therefore, each of the six days was a long period, of a thousand or an hundred years, the seventh day must have been of the same duration; an idea which is glaringly inconsistent with the narrative of Adam's history.—We may add, that in the sacred volume, the misery and destruction of the creatures are represented as the bitter fruits of man's transgression; and how then can we admit, that the catastrophes belonging to the formation system, were antecedent to the introduction of sin, and even to the creation of man?

Instead of assigning such high antiquity to the whole of the strata, why may we not rather suppose, that a great proportion of them, particularly such as contain organic remains, might be formed at the era of the deluge? We are far from adopting on this subject the crude notions of Dr. Woodward; yet we are persuaded, that he, and Mr. Howard and others, who ascribe to the deluge the principal changes which the crust of our globe has undergone, in so far come nearer the truth, than those who would throw back those changes into long ages that preceded the creation of man, involving them in the darkness of the chaos. Aware that our sentiments on this subject differ materially from those of a great proportion of our literary friends, we would beg of them a patient hearing; that they may not condemn our remarks, till they have candidly weighed them.

It is common to ascribe to the deluge only the formation of some alluvial beds; nay, some authors will scarcely allow it a share even in forming the alluvium. A writer in the Philosophical Journal, for July, 1820, alleges that, "according to Moses," the deluge was only "a quiet effusion of water upon the surface of the earth;" by which "the surface was not torn up or moved, so as in any material degree to disturb and root up the vegetable races;" and which did not wash away even the vegetable mould. In proof of which view of the deluge, the writer

asserts, that "Noah on quitting the ark, or very soon after, planted a vineyard."—The charge which that writer prefers against Professor Buckland, of "not having carefully considered the words used by Moses in describing the Noachian deluge," may with great justice be retorted upon himself. From the notice taken of Canaan the son of Ham, in what is said about the vineyard, we may infer, that it was not planted till several years after the deluge. Indeed, had the deluge been nothing more than what that writer conceives, the wonder is, why Noah would think of planting a vineyard at all; as he had his choice of thousands of vineyards, left by the antediluvians, and rendered more fertile by a slight coating of mud!

Had Moses given no intimation of violent means employed for the submersion of the earth, the simple fact which he states, that the waters overflowed the whole globe for an hundred and fifty days, and the lower parts of the land much longer, implies great and extensive changes. Were our present strata submerged so long in the ocean, exposed to the action of the waves and currents, besides the agitation occasioned by the rising and falling of the waters, could we suppose that the surface would scarcely be disturbed? On the contrary, might we not expect, that the alluvial beds, with vast quantities of the softer strata, would be wholly dissolved, or terribly broken; and that even the solid rocks, or masses of strata, dashing against one another, would to a great extent be ground to powder? Such effects must have been produced by the deluge, even if waters had been created on purpose to drown the world, to be afterwards annihilated when they had fulfilled their commission. But how much greater must the catastrophes have been, when the waters of the ocean were employed to cover the dry land? We are expressly informed by the sacred historian, that while "the windows of heaven were opened," to pour down rain, "all the fountains of the great deep were broken up;" words evidently intimating, that the waters rushed up from the depths of the

ocean, if not from the interior of the globe, in order to overflow the earth; which implies, that the bed of the sea was elevated, and the land proportionally depressed, and consequently that the strata were extensively broken and deranged. Moses, indeed, repeatedly states, that the earth was destroyed, as well as its inhabitants; and the Apostle Peter, in the last chapter of his Second Epistle, considers that destruction of the earth by water, as somewhat analogous to the final destruction of the globe by fire; and since he describes the latter as a dissolution of the substance of the earth, particularly of its crust, where the works of man are carried on, we must, to preserve the analogy, understand the former of a similar dissolution, though by another element.

As collateral proofs of the extent of the revolution effected by the deluge, we may notice the abridgment of the life of man immediately following, and the change that seems to have taken place even in the atmosphere. No mention is made of rain before the deluge, but only of mist employed to water the ground; and as the rainbow was appointed a token of God's covenant with Noah, it seems probable, that it then appeared for the first time, and consequently, that the state of the atmosphere was materially altered. The shortening of human life may be presumed to be connected with this alteration, and with corresponding alterations in the earth's surface, occasioning great changes of soil and climate.

Even the duration of the deluge is a presumptive evidence, that it was intended for other purposes than the mere destruction of the inhabitants of the globe. The waters prevailed on the earth an hundred and fifty days (including, it would seem, the forty days during which it continued rising); after the ark took the ground, above two months more elapsed, before the tops of the mountains were distinctly seen, emerging from the ocean; and other four months were almost expired, before Noah and those under his charge were permitted to

quit the ark, which had now been their habitation upwards of a year. Many years, indeed, might revolve, ere the ocean subsided to its present level. Now, if the object of the deluge was merely to drown the inhabitants of the world, that might have been accomplished in a few days; and a week or two might have sufficed to dry the earth, had there been only "a quiet effusion of water upon its surface." Is there not, then, strong ground for presuming, that the globe was so long immersed, to effect the most important changes in its crust; that during the deluge, the old strata were extensively demolished, and new strata formed out of their ruins; and that, as the ocean subsided, the new strata rose, experiencing in their rise those breaks, undulations, and other irregularities, with which they are marked?

To establish the theory here proposed, many queries demand to be answered, and not a few objections require to be met. Our limits will not allow us to enter very fully into the subject; but the following remarks may serve to elucidate and confirm the general ideas now thrown out.

If it be asked, To what extent were the ancient strata demolished? We reply; that probably the whole were dissolved, except the primary rocks, containing no organic remains. Dolomieu, an accurate observer of nature, notices, that a great catastrophe seems to have taken place after the birth of the primitive rocks, and before that of the derivative; that the shell of the earth has been broken through by some vast shock, and the strata, originally horizontal, thrown up to a great height, some vertically, and others obliquely; thus forming the principal inequalities on the earth's surface. Mr. Greenough, after quoting these expressions, makes this judicious remark: "Without assenting to every part of this doctrine, I cannot but consider the almost universal occurrence of conglomerate and greywacké on the confines of what are called primitive rocks, as one of the most important and striking facts yet established in geology: it

seems to prove, that, at the epoch at which these beds were formed, a deluge took place, &c."* The deluge which formed these conglomerate beds, is supposed by Mr. Greenough to have been more ancient than "that which determined the present outline of the earth;" but why may we not regard it as the very same? The beds alluded to seem to mark the extent to which the primeval strata were dissolved by the deluge.

But how could the deluge dissolve so large a portion of the earth's ancient crust? To this we answer, that the beds so demolished might be much softer than some of our secondary strata now are; and might bear some analogy to our alluvial beds. The ancient world may be presumed to have been more fertile than the present; as the people of that world lived to a great age, though they were not, as far as we know, permitted to use animal food. Hence it is probable, that the primeval earth was covered with a rich and deep soil; and it is by no means unlikely, that vast beds of clay, of sand, of marl, or calcareous matter, as well as quantities of gravel, were lying over the solid strata: and even the latter might not then have acquired their utmost hardness. If such was the case, it is easy to see, how sufficient materials might be supplied, for forming our strata of sandstone, limestone, and shale; without attributing to the waters of the deluge any preternatural power of decomposition.

If the inquiry be made, How could the antediluvian world furnish the inconceivable quantity of animal and vegetable matter, contained in our present strata? We reply, that if we take into consideration the superior fertility of the ancient world, the difficulty will vanish. Even our present earth could perhaps yield a supply of such matter, little or nothing short of the quantity observed. Were the vast forests of America, for instance, rooted up, and floated in masses, they would go far towards furnishing materials for coal strata, equal

* Greenough's Geology, p. 212.

to all the coal beds hitherto known; and no doubt the antediluvian forests were far more extensive and luxuriant.—As trees are often found lodged at a great depth, in the channels of rivers, and at the bottoms of lakes, we need scarcely inquire, how the masses of wood could be deposited at the bottom of the ocean, instead of all floating at the top. Yet we may notice, that the trees being torn up with all their roots, branches, and leaves, would naturally become much clogged with the mud or clay of the soil in which they grew; and this clay would not only facilitate the deposition of the vegetable masses, but supply materials for the shale beds which uniformly accompany coal. The leaves and small plants, floating in the upper part of the mass, would occasion those vegetable impressions found in the coal shale, immediately over each bed of coal; and often in the coal itself. Some of the thinner seams of coal, as the Maybecks seams, appear to owe their origin to floating masses of branches, shrubs, and small plants. The process by which such vegetable matter might be converted into coal, is well described by Mr. Parkinson, in the First Volume of his Organic Remains. The coal beds would be formed by successive floating masses of wood, beds of clay or sand being interposed between them.

The exuberance of animal life in the ancient world, may be presumed to correspond with that of vegetation. Immense quantities of shell-fish, with the exuviæ of those of former ages, being strewed along the shores of the seas and the rivers, would, at the breaking up of the strata, be swept away by the waters; intermixed with the sand, marl, or clay, on which they reposed, now destined to be their matrix; and masses of animal matter, including shells, remains of fishes, &c., after floating for some time, would be deposited in the beds, and become the nuclei of future nodules of stone.

Some may be ready to ask, Why are the beds so regular, and in many instances so homogeneous? Why do we not find them presenting

a more confused mixture of different substances? These questions it is not very difficult to answer. Among subtances set afloat in a mixed state, an elective attraction, as it has been called, tends to draw together such parts of the mass as are of the same nature. This we see exemplified on our own beach; where the sea often deposits seams of burnt alum shale, of mud or clay, of drift coal, of white sand, of brown sand, of gravel, &c.; each tolerably homogeneous, as far as it goes. We see also quantities of sea-weed deposited in beds, instead of being confusedly dispersed along the shore; and quantities of shells, often of one species, arranged in a similar form. The same phenomena, but on a far grander scale, appear in the formation of the secondary strata; the clay, the sand, the lime, the wood, &c., having settled to the bottom in separate strata, or extensive lenticular masses, each running to a thin edge.

Again, it will be demanded, How could the waters of the deluge hold so much matter in a state of solution? To this we reply; that these waters being composed of the whole contents of the ocean, and of all the lakes and rivers of the world, with all that the atmosphere could supply, not to speak of what might issue from caverns in the interior of the globe; this immense collection would suffice to float a quantity of matter, adequate to form at least a very large proportion of the secondary strata; especially as, from the manner in which the shells and pieces of wood are distributed in the beds of shale, &c., the solution seems to have been, in some instances, very thick and slimy, containing but little water. Besides, it is not necessary to suppose the whole materials of the strata to be suspended in the waters at once: they might be dissolved and deposited in successive portions, according as the ocean rose higher and higher, and extended its depredations on the ancient crust of the globe; and the waters which deposited the first part of the strata, would thus be set at liberty, to assist in dissolving and arranging the last. Thus far we

may admit the doctrine of formations; that the beds may have been deposited in successive assemblages, and there might be only one assemblage or series afloat at a time, in any particular place or region; though we have no right to suppose, that any one series extended round the whole globe, so as to constitute a universal formation.

We have already (§ 20) anticipated the queries that may be made, respecting the agent employed in breaking up the crust of the earth, and subsequently elevating the new formed strata. These operations were most probably effected by volcanic agency, or some expansive force acting from below. The bed of the sea was thus heaved upwards in various places; and this could not be done without a corresponding depression of the land; for wherever any portion of the earth's crust was elevated, the chasm beneath it would naturally be filled up with matter rushing in, or pressed in, from all sides; and this matter being abstracted from under the adjoining strata, the latter would necessarily sink. The violence attending these operations, would greatly facilitate the dissolving of the strata, in the early stages of the deluge; while the strata that remained undissolved, would be thrown into that wild confusion which the primary rocks now present; some masses being raised on their edges vertically, and others at high angles, as we see in accumulated fragments of broken ice. In the later stages of the deluge, when a great part of the new strata had been deposited, the expansive force might, in many instances, continue to act on the same parts of the earth's crust; and consequently would produce dry land where the ancient ocean had flowed, while large portions of what had been dry land, sunk down, and became the bed of the present ocean. Yet, in other instances, we must suppose the volcanic agency to have changed its direction; allowing the former bed of the ocean, which it had elevated, to sink down and become the bed of the ocean still; and causing what had been dry land, to rise and become dry land again.

This we may presume to have been the case with the mountains of Armenia, where the rivers Euphrates and Tigris, mentioned in the description of paradise, have their sources; and where the ark took the ground. Yet, it is likely, that these mountains, and many of our present mountains, acquired by the deluge an elevation which no mountains had attained before; owing principally to the way in which masses of the earth's crust were then raised on their edges. The peaks of the Himalay mountains, the most lofty in the world, are huge fragments of primary strata, elevated at a high angle; as appears from Mr. Fraser's paper in the Geological Transactions, Vol. V. Other lofty peaks, such as those of the Andes, are craters of volcanoes; of which there were probably none before the deluge.

While the new strata were rising, they would unavoidably be bent, cracked, and broken, in various places; especially as the expansive power that heaved them up, could not be expected to act on every part with equal force; and wherever that power was suddenly suspended or withdrawn, a subsidence would take place, which would greatly increase the dislocations and bends. As the rise of the strata, corresponding with the subsiding of the waters, took place in successive stages, this would occasion breaks and veins of different dates, as well as upfillings, unconformable strata, and other irregularities. Hence, we find veins and masses of trap, and other unstratified rocks, of different ages. Such veins, as already intimated (§ 20), we conceive to have been forced upwards in a state of fusion; and the flat masses might originate in the overflowing of the veins; and where this overflowing matter became covered with new depositions, such rocks would appear stratified. We need not doubt, that the interior of the globe, which supplies matter for so many volcanoes, could be made to yield abundance of materials for trap dykes, metalliferous veins, and unstratified rocks. Whether granite belongs to this class of rocks, or not, we do not stop to inquire.

The abrasions or denudations of the strata, appear to have been occasioned, chiefly by the rushing or hasty retiring of the waters, from a higher to a lower position, as the strata ascended; and the materials abraded, with fragments detached at the breaks, and lighter matter yet floating or held in solution, would form the alluvial beds; the higher regions generally supplying materials for the alluvium of the lower. The quantity of gravel required for the alluvium, need not cause any serious difficulty, if we consider, that the waters of the deluge might not retire from the lower regions, till many years after Noah quitted the ark. The gravel of the old world would suffice for the ancient breccias and conglomerates. Perhaps some of the phenomena observed, must be explained by supposing, that the strata in some places have been twice submerged; and those who make the strata dance up and down at pleasure, to produce fresh and salt water formations, cannot object to this double submersion.

If it be asked, How could the earth, after such a catastrophe, so soon become a firm habitation for man and beast? We reply; that since the consolidation of the strata was not the work of time, as we have already seen (§ 12), there is little or no difficulty in the case, especially as the volcanic heat might serve to accelerate their consolidation. Besides, the place where the ark rested, might consist chiefly of primary strata; and men might live on the mountains, till the valleys were fit for their reception.

Again, it will be inquired, How was the vegetable world preserved, and so quickly restored? Why were not all vegetables, and even all marine animals, overwhelmed by the breaking up of the earth's crust, or destroyed by the volcanic heat? We answer; that no doubt a great proportion of the vegetables and marine animals perished, and several species, and even genera, appear to have become extinct; but others were preserved, like the ark, towards the surface of the waters, in sufficient quantity for replenishing the new world.

The seeds and roots of vegetables, and perhaps whole trees and shrubs, would float in considerable quantity; and being left by the retiring waters, mixed probably with a fine loam, would speedily vegetate, and deck the new earth with verdure. In like manner, the fishes, and other marine animals, though vastly reduced in numbers, would still suffice to stock the new seas, lakes, and rivers. It need not be objected, that the salt water would kill all the vegetables; for the salt water was then diluted in fresh water; nay, it would seem, from the quantities of salt found imbedded in the strata, that it then deposited much of its salt in a crystallized form.—As to the effect of the volcanic heat on animal and vegetable life, the chief region of that heat must have been at such a distance from the surface, that it could have no fatal influence; except in a few spots, where the fused matter overflowed the fissures of the strata, and formed overlying masses: and even there it would soon cool, on approaching the surface. It is well known, that animals and vegetables live and thrive on the skirts of Ætna, Vesuvius, and other volcanoes; and the volcanic heat at the deluge might have a genial influence, occasioning a more rapid restoration of the vegetable world, as soon as the land emerged from the ocean. We need not then wonder, that at the distance of four months after the ark ceased to float, the dove should find a fresh olive leaf, which she plucked off and brought to Noah. And let it be remembered, that the top of mount Ararat, whatever it may be now, could not then be cold and bleak; for it would enjoy the same atmosphere in point of density and warmth, as that of any low island now situated in the same latitude.

Further, it will be urged, as a formidable objection against our theory, Why are not the remains of quadrupeds found in great quantities, imbedded in the strata? Why, especially, are no remains of man found in them? To these questions we reply; that if, in most instances, what was dry land before the deluge became the bed of the sea after it,

and *vice versâ*, this is a good reason why the organic remains of our present strata should consist chiefly of marine productions; the remains of land animals being found sparingly, as they would be chiefly imbedded in the strata which now compose the bottom of the ocean. Besides, during the gradual rise of the waters, both men and beasts, especially the former, would betake themselves for refuge to the hills and higher grounds; where they might survive the first catastrophes of the earth's crust, and consequently escape being imbedded in the lower strata. Being afterwards swept away in vast crowds, when the waters reached the highest eminences, they would form floating masses of animal matter, in which the most fat and bulky animals, as the elephant, rhinoceros, &c., would hold an important place. It is a common, and very probable opinion, that the raven which Noah sent out, found sustenance by feeding on the floating carrion. Some portions of this animal matter, especially when loaded with mud, might be expected to sink, and be imbedded in the newest strata; in which situation animal remains have been discovered, in one of the supposed fresh-water formations of the Paris basin. If Mr. Whitby's account of the discovery of some remains of the rhinoceros, found in 1816, imbedded in a mass of clay in the solid limestone near Plymouth, be correct, a mass of such animal matter, loaded with mud, must have been inclosed in that rock whilst it was forming. We have in our possession, a tooth resembling one of the grinders of a horse, but smaller, which was found in the summer of 1821, with some ribs and other bones, imbedded in a seam of marl in the magnesian limestone, at Pallion quarry, near Sunderland. The seam containing the bones was twenty feet below the surface of the solid rock, and sixty-five feet below the surface of the ground, and the spot was at a great distance from the original front of the quarry; nor was there a vestige of any cave or vertical fissure, by which the bones could be introduced. These particulars we learned from Mr. Baker of Wearmouth, an intelligent gentleman, who examined the rock when the bones were taken out.

But most of the masses, composed of remains of quadrupeds, appear to have kept afloat, till all the regular strata were deposited, and till breaks and fissures began to exist even in the newest strata. Floating on the surface of these strata, quantities of bones, accompanied with softer animal matter, which protected them from being water-worn, were lodged in crevices and openings; and these openings, whether caused by breaks, or by the shrinking of the rock while it was consolidating, being most numerous in limestone, it is in calcareous rocks chiefly that such remains occur. At that era, the bones found at Kirkdale, were floated into the cavern. They present, as might be expected in a collection detached from the floating masses, a confused mixture of bones and fragments of bones, of animals of various kinds, large and small, herbivorous and carnivorous, and even of fowls as well as beasts; accompanied with marly clay, resulting chiefly from the decomposition of animal matter. As far as we can judge, from descriptions of the animal remains in the German caverns, in the clefts of the rock of Gibraltar, and in several places on the shores of the Mediterranean, they appear to be similar collections, deposited in the same way. If the bones in the German caverns had not been floated, how could they be found in considerable quantity, lodged on the sides and towards the roof, at a great height from the floor? These remains being deposited before the alluvial beds were formed, are not accompanied with sand and gravel; but a great proportion of the animal masses having continued floating till the denudations commenced, and the alluvium began to be deposited, they were lodged in it at various depths. The bones left near the surface, among which might be a quantity of human remains, would soon be decomposed; while the relics deposited at greater depths, particularly those of the larger animals, would be preserved. It is unnecessary to inquire, whether the elephant, rhinoceros, hyæna, &c., were floated hither from tropical climates; for we have no right to

presume, that the climate of this region was as cold before the deluge as it is now.

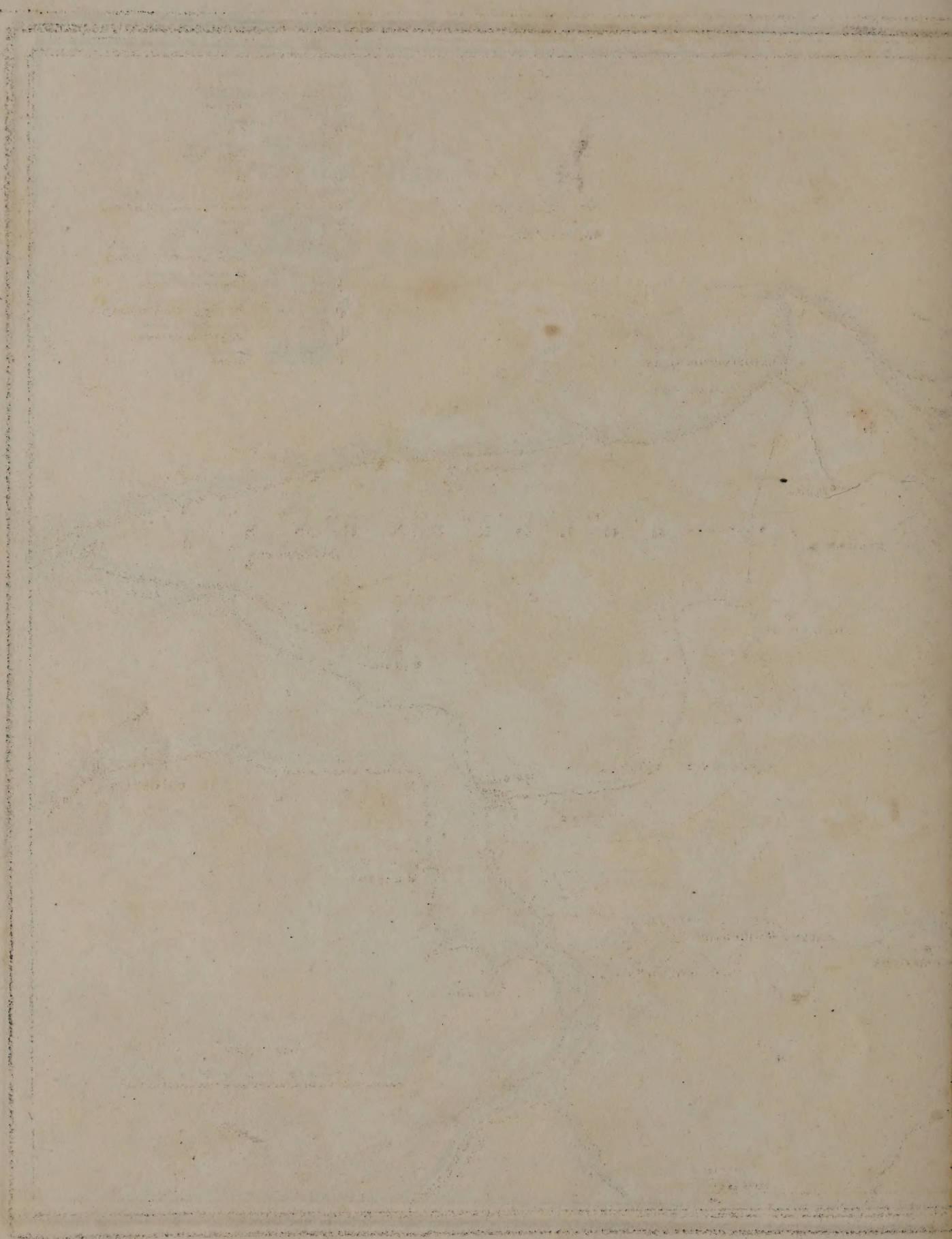
Most geological authors lay it down as a kind of axiom, that no human remains exist in the strata. It is by no means certain, however, that the writers who have spoken of finding human bones in the clefts of the rock at Gibraltar, and in similar collections, were all mistaken. The recent discovery of human skeletons, imbedded in a grey limestone in the island of Guadaloupe, leads us to think, that fossil human remains have been found elsewhere, and may yet be found in greater quantity. Attempts have been made to set aside the force of this fact, by supposing that the Guadaloupe limestone is quite a modern concretion; but such suppositions, which vary according to the fancy of each writer, cannot be opposed to the plain facts detailed by Mr. Konig, in the Philosophical Transactions for 1814.

Several other questions might be discussed, to elucidate our theory. We might be expected, to notice the difficulty of fixing the line of demarcation between the primary and secondary strata, and to advert to other phenomena requiring explanation. We will not, however, pursue our researches further at present; but leave it to others better qualified, or to ourselves at another opportunity, to fill up the outline now sketched. Future discoveries may perhaps overturn some parts of our theory; but whatever modifications it may be destined to undergo, we indulge a hope, that, as it is adopted upon a careful examination of facts, the principal parts of it will eventually be established.

It gives us no small pleasure to observe, that the geological facts which have come under our review, do not contradict but confirm the sacred scriptures; and if our labours have served to excite in our readers a greater veneration for the works, and the word, of the Almighty, our highest object has been attained.

Geological Map
OF THE
YORKSHIRE COAST
WHITBY
SCARBOROUGH
HARTLEPOOL
LOFTHOUSE
GUISBOROUGH
STOCKTON
STOKESLEY
PICKERING
MALTON
KIRKBY MOORSIDE
HELMSLEY
EASINGWOLD
THIRSK
NORTH ALLERTON
YORK
VALE OF PICKERING
VALE OF MOWBRAY
PLAIN OF CLEELAND
HIGH W
Saltwick
Kettleness
Sandsend
Ugthorpe
Boulby
Skelton
Runswick
Staithes
Mulgrave
Aislaby
Sneaton
Ruswarp
Egton
Goldsland
Freebrough Hill
Danby Beacon
Danby
Castleton
Commondale
Cock Heads
Ralph Cross
Rosedale
Fryup
Farndale
Blakey Topping
Bride Stones
Silhergate
Lockton
Thornton
Cropton
Sinnington
Keldholm
Gillamoor
Hutton Buscel
Harwood Dale
Maybecks
Langdale End
Silpho
Hackness
Ayton
Brompton
Ebberston
Wilton
Knapton
Thorp Basset
Scagglethorp
Settrington
Malton
Rye
Castle Howard
Terrington
Sheriff Hutton
Dalby
Crake
Coxwold
Rievaulx Abbey
Wass
Whitestone Cliff
Kirkby Knowle
Hood Hill
Rowlton Scar
Hambleton Hills
Osmotherley
Swainby
Hawnby
Silton
Seingdale
Whorl Hill
Carlton
Hutton Rudby
Middleton
Crammoor
Wain Stones
Cold Moor
Tripsdale
Bransdale
Ingleby
Greenhow
Burton Head
Langbargh Ridge
Rosebury
Kildale
Commondale
Bilsdale
Bloworth Moor
Lazenby
Easby Moor
High Cliff Nab
Redcar
Coatham
Saltburn
Skinningrave
Seaton Rocks
Salt Scaurs
Tees Mouth
Preston
Yarm
Middleton Spaw
Dinsdale
Sockburn
Entercommon
Croft
Robin Hoods Bay
Fyling
Hawsker Bottoms
Ravenscar
Cloughton Wyke
Hayburn Wyke
Cloughton
Burniston
Flask Inn
Stoupe
Carlton
Folkton
Sturton
Ganton
Sherburn
Westerton
Knapton
Thorp Basset
Scagglethorp
Settrington
Langton
Kirby Grindalythe
Birkham
Westow
Bird
Norton
Dalby
Sheriff Hutton
R. Derwent

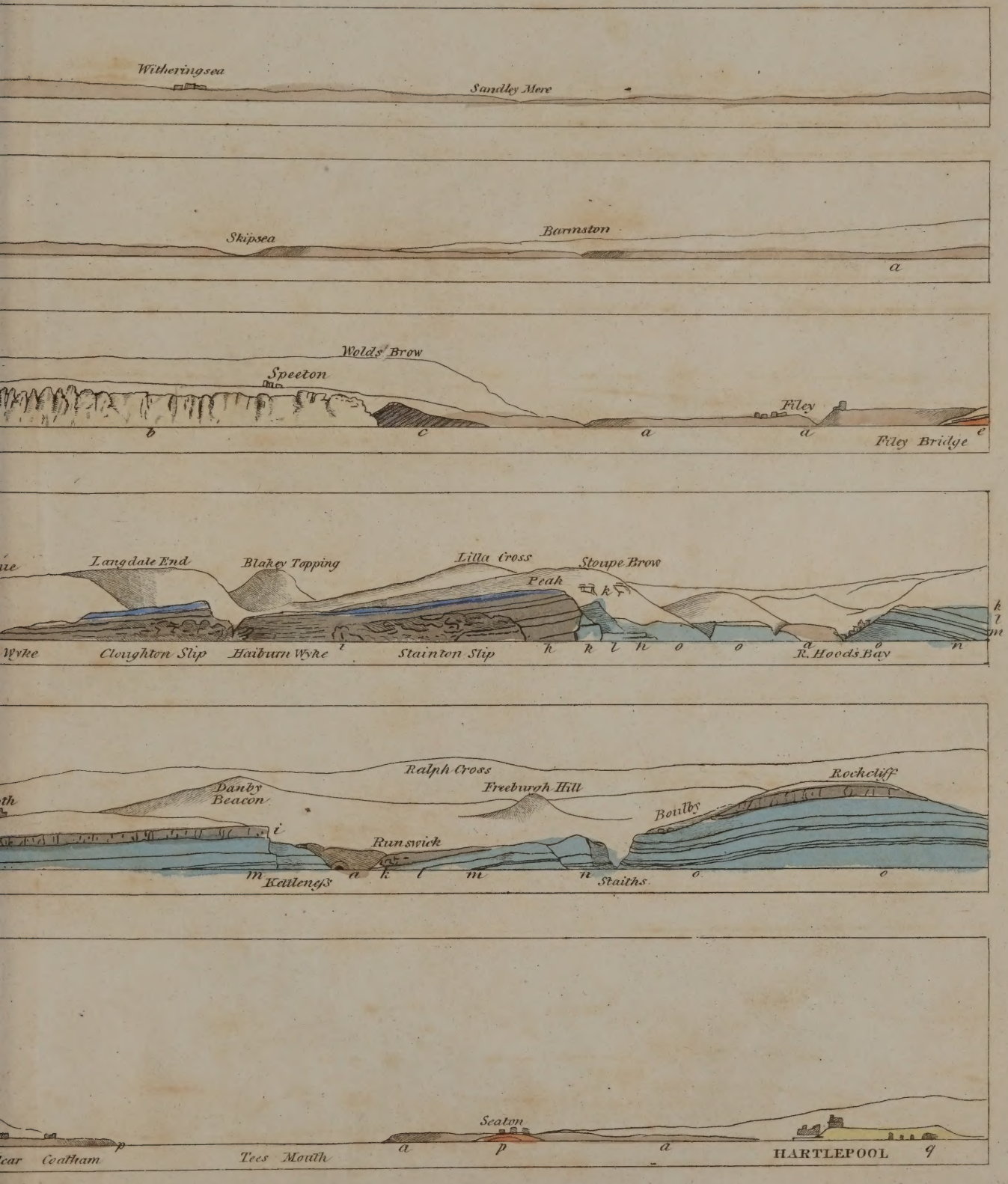
Engd by W.H. Lizars Edinr



Section of the Strata from

a Alluvium b Chalk c Upper Shale d Oolite e Limest. & Calc. Sandst. f 2nd Shale g Ironst. & Sandst. h Blue Limest.

the Spurn to Hartlepool.



Pl. I.

Fig. 1

Fig. 2

Pl II.

Pl. III.

Pl. IV.

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Pl. VI.

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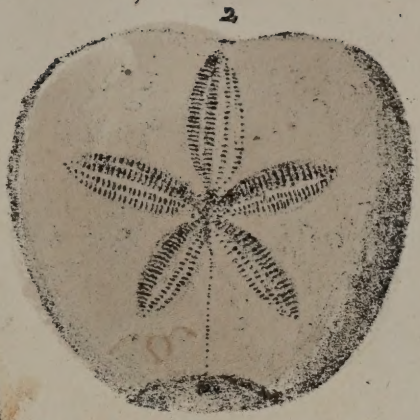
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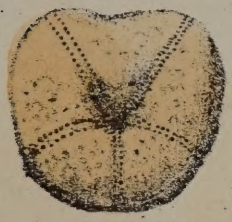
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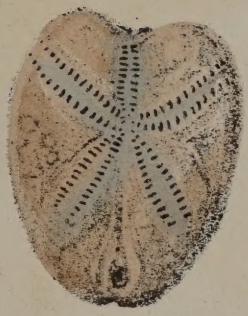
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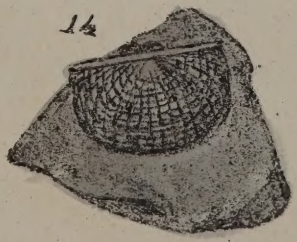
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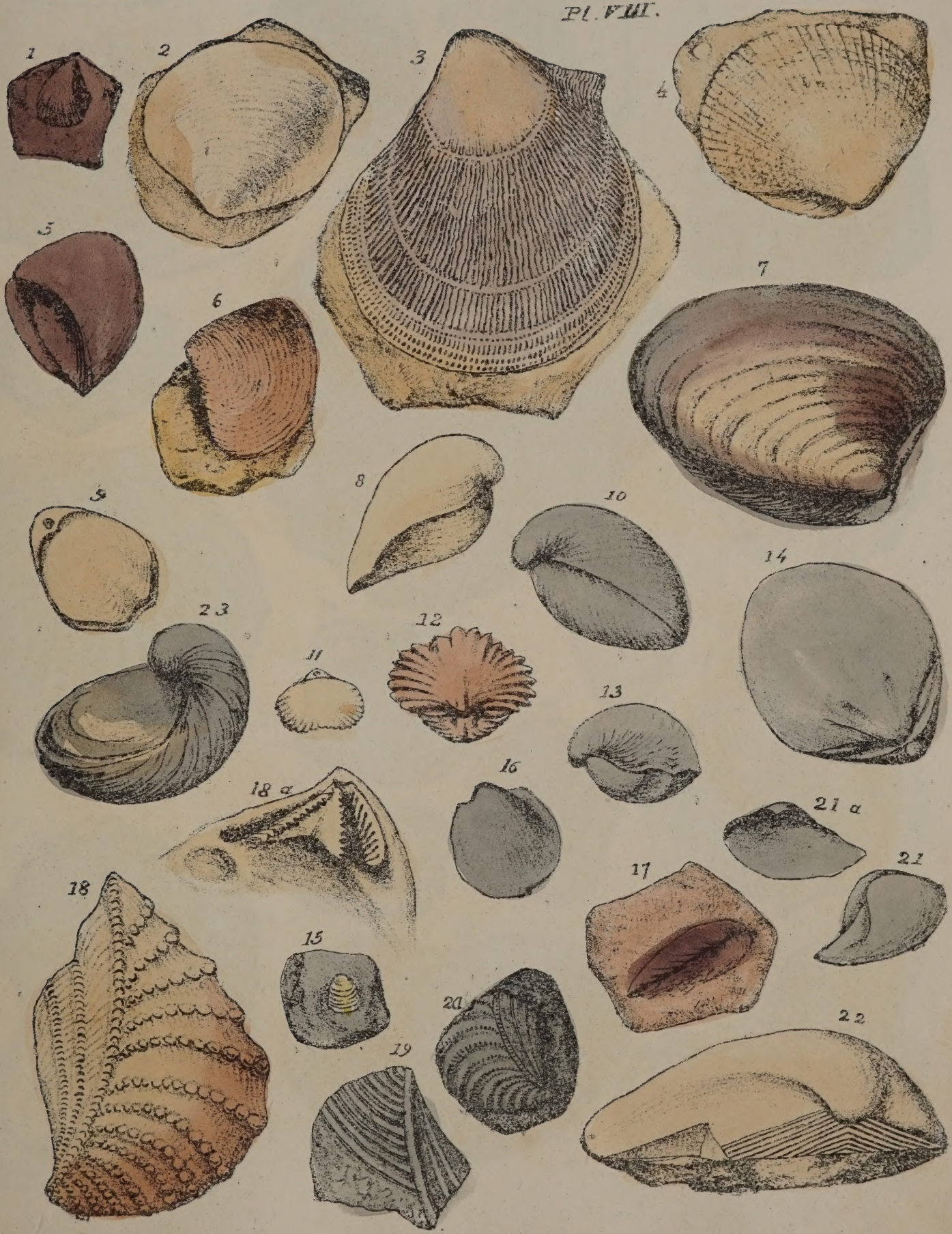
Pl. VIII.



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Pl. X.

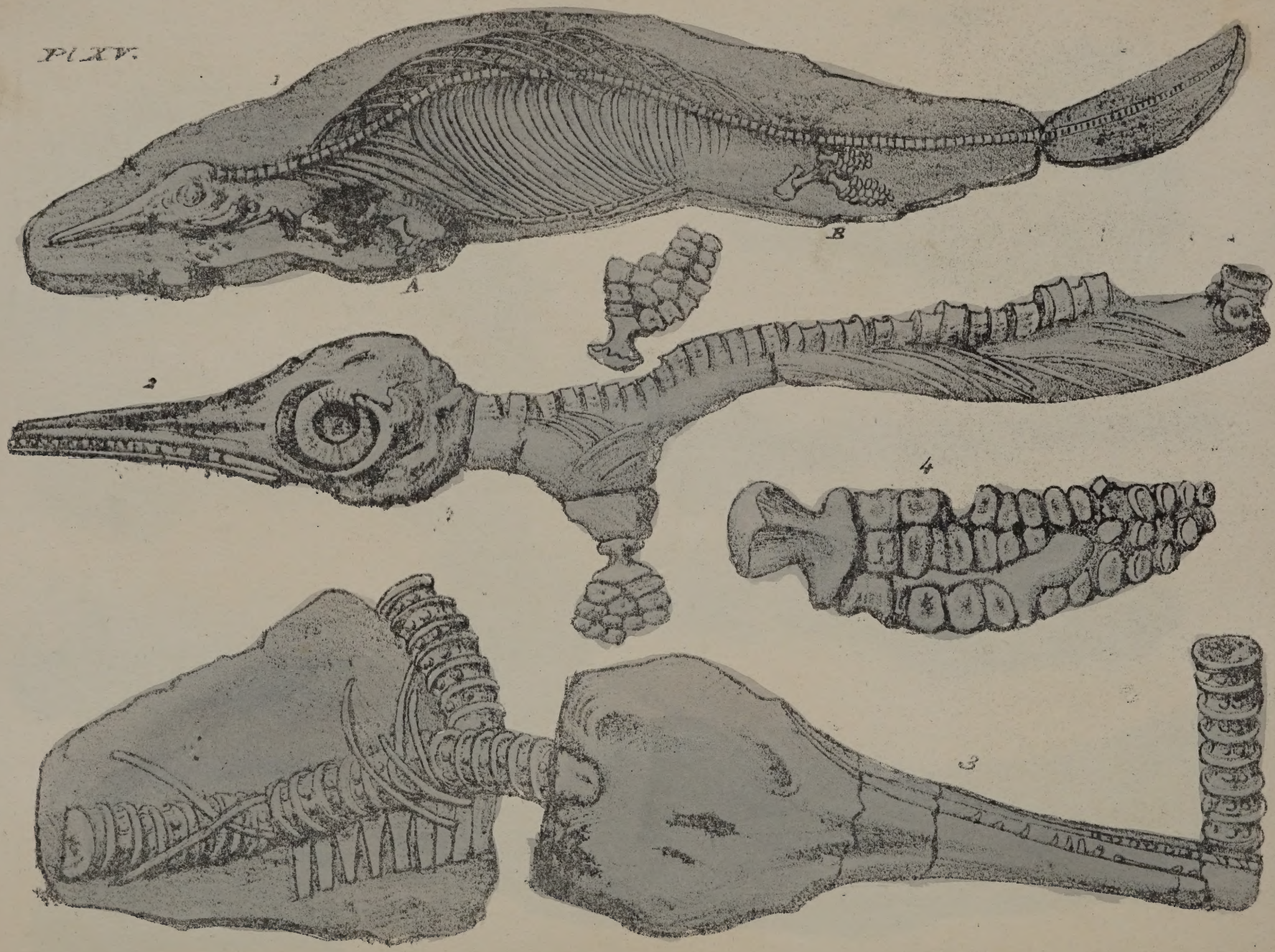
Pl. XI

Pl. XII.

Pl. XIII

Pl. XIV.

PLXV.



Pl. XVI.

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EXPLANATION

OF THE

PLATES.

PLATE I. Page 19.

FIG.
1. Contortions in alluvial clay and sand near Skipsea.

FIG.
2. Singular appearance of alluvial beds near Cowden.

PLATE II. *Vegetable Impressions.* P. 182, &c.

FIG.
1. From Saltwick ironstone.
2. From the same.
3. From the same.
4. From the coal shale at Fryop.

FIG.
5. From the coal shale at Fryop.
6. From Saltwick ironstone. Apparently the head of the plant No. 2.
7. Leaf of the *scolopendrium.* Saltwick.

PLATE III. *Vegetable Impressions, &c.* P. 182, 184, &c.

FIG.
1. Plant from the Castleton coal shale.
2. Fern in sandstone, from near Sandsend.
3. Reed, or cane, from High Whitby.
4. Impressions in coal shale.

FIG.
5. Arrow head impressions in sandstone.
6. Petrified wood, with a knot; from the alum shale.
7. Nut; from a nodule in sandstone.

PLATE IV. *Zoophytes, &c.* P. 191, 195, &c.

FIG.
1. Simple madrepore, or alcyonite. Chalk.
2. *Madrepora ananas.* Helmsley oolite.
3. Fig-shaped madrepore, or alcyonite. Oolite.
4. Turbinated madrepore. Malton oolite.
5. Button-shaped madrepore. Chalk.

FIG.
6. Madrepore with open pores. Chalk.
7. Fungiform madrepore. Oolite.
8. Flower-shaped ditto. Malton oolite.
9. Group of cylindrical bodies, like petrified tangle. Runswick.

PLATE V. *Encrinites and Pentacrinites.* P. 200, &c.

FIG.
1. Briaræan pentacrinite. Robin Hood's Bay.
2. Pentagonal stars, or joints of pentacrinites.
3. Rare fossil. Malton oolite.

FIG.
4. Polished section of an encrinite.
5. Head of an encrinite.
6. Briaræan encrinite; with belemnites.

Plate VI. *Echinites, &c.* P. 205, &c

FIG.
1. *Cidaris papillata.* Malton oolite.
2. *Cor anguinum.* Chalk.
3. *Cidaris diadema.* Oolite.
4*A*. New species of echinite. Ditto.
4*B*. Under side of ditto.
5. A species from calcareous sandstone.
6. A flint echinite, with rows of small spines; perhaps casts of the pores.

FIG.
7. A spinite. Malton oolite.
8. Bent spinites. Kirkby Moorside oolite.
9. Flint echinite; from the alluvium.
10. *Cidaris corollaris.* Flint: alluvium.
11. Substance like a hazel nut. Oolite.
12. Petrified wood. Oolite. P. 214, Note.
13. *Conulus albogalerus.* Flint.
14. *Anomia producta.* Alluvium. P. 230.

Plate VII. *Bivalves.* P. 217, &c.

FIG.
1. *Solen ensis.* Lowest shale.
2. Muscle; from the calcareous sandstone.
3. Pyritous musele. Alum shale.
4. *Mytilus avicula.* Malton oolite.
5. *M. lithophagus.* Oolite.
6. *Mya ovata?* Malton oolite.

FIG.
7. Cast of a muscle; from Coldmoor.
8. Donax; from the same place.
9. Curious cast; from the oolite.
10. *Mytilus ungulatus.* Oolite.
11. Donax; from the oolite.
12. Ribbed bivalve. Oolite.

Plate VIII. *Bivalves.* P. 219, 222, &c.

FIG.
1. Shell resembling a cockle. Ironstone.
2. *Tellina crassa.* Malton oolite.
3. *Plagiostoma rigida.* Ditto.
4. Cockle; from the Malton grey limestone.
5. *Cardium pectinatum.* Alum shale.
6. *Venus rugosa?* Dogger.
7. *Unio Listeri* of Sowerby. Alum shale.
8. *Anomia arcuata.* Chalk.
9. ——— *intermedia.* Ditto.
10. ——— *ovoides.* Second shale.
11. ——— *compressa.* Grey limestone.
12. ——— *tetraedra.* Sandstone.
13. ——— *semiglobosa.* Chalk.

FIG.
14. *Anomia ornithocephala?* Alum shale.
15. Pyritous shell. Alum shale. P. 231.
16. *Cardium?* Oolite.
17. *Tellina?* Dogger.
18. *Trigonia clavellata.* Pickering oolite.
18*a*. Hinge of the right valve.
19. *Trigonia costata.* Oolite.
20. Trigonia; from the dogger.
21. *Arca rostrata.* Alum shale.
21*a*. Hinge of the same.
22. Valve of a large ark. Oolite.
23. *Gryphæa incurva.* Alum shale.

Plate IX. *Bivalves.* P. 232, &c.

FIG.
1. *Pecten Maltonensis.* Oolite.
2. ——— *Roseburiensis.* Sandstone.
3. ——— *sulcatus.* Oolite.
4. ——— *cygnipes.* Flat valve. Alum shale.
5. *Chama calcarata.* Ironstone. P. 230.
6. *Pecten cygnipes.* Raised valve.
7. ——— *inequicostatus.* Oolite.
8. ——— *subrufus?* Sandstone: Boulby.

FIG.
9. *Pecten varius.* Oolite.
10. ——— *Scarburgensis.* Sandstone.
11. ——— *pusio?* Oolite.
12. ——— *fibrosus.* Grey limestone.
13. *Ostrea?* Oolite.
14. ——— *diluviana.* Sandstone.
15. Donax-formed shell. Lowest shale. P. 221.
16. *Ostrea gregaria.* Oolite.

PLATE X. *Bivalves.* P. 237, &c.

FIG.
1. *Ostrea Sinensis?* Upper shale.
2. ——— *unguis.* Ditto.
3. *Ostrea?* Oolite.
4. *Gryphæa dilatata.** Sandstone.
5. *Pinna capricornus.* Ditto.
6. ——— *folium.* Lowest shale.

* The shells in the chalk resembling gryphites, noticed p. 240, belong to the new genus INOCERAMUS.

PLATE XI. *Univalves.* P. 242, &c.

FIG.
1. *Trochus magus?* Oolite.
2. *Nerita maxima?* Ditto.
3. *Buccinum flammeum?* Ditto.
4. *Trochus radiatus?* Blue limestone.
5. *Nerita marginata?* Oolite.
6. Cast of a *cirrus.* Grey limestone.
7. *Turbo?* Oolite.
8. *Turbo tumidus?* Oolite.
9. ——— *striatus (Melania striata).* Ditto.
10. *Melania Heddingtonensis?* Ditto.
11. *Turritella conoidea.* Ditto.
12. *Patella lævis.* Alum shale.
13. *Dentalium entalis.* Lowest shale.
14. Group of serpulites. Dogger.

PLATE XII. *Multilocular Shells.* P. 246, &c.

FIG.
1. *Ammonites Hildensis (Walcotii).* Alum shale.
2. ——— *ingens.* Pickering oolite.
3. ——— *communis.* Alum shale.
4. ——— *subtriangularis.* Lowest shale
5. ——— *Silphouensis.* Sandstone.
6. *Ammonites cornucopia.* Alum shale.
7. *Nautilus subcarinatus.* Ditto.
8. *Ammonites tenuicostatus.* Ditto.
9. ——— *Pickeringius.* Oolite.
10. ——— *Maltonensis.* Oolite.

PLATE XIII. *Multilocular Shells.* P. 248, &c.

FIG.
1. *Nautilus Whitbiensis.* Alum shale.
2. ——— *pompilius.* Ditto.
3. *Ammonites subarmatus.* Ditto.
4. ——— *ovatus.* Ditto.
5. ——— *concavus.* Ditto.
6. ——— *planicosta.* Lowest shale.
7. *Ammonites elegans.* Alum shale.
8. ——— *Mulgravius.* Ditto.
9. ——— *armatus.* Ditto.
10. ——— *Rowlstonensis.* Sandstone.
11. ——— *Clevelandicus.* Alum shale.

PLATE XIV. *Multilocular Shells, &c.* P. 248, &c.

FIG.
1. *Belemnites vulgaris.* Alum shale.
2. ——— *fusiformis.* Upper shale.
3. Section of *b. vulgaris.*
4. *Belemnites excentralis.* Oolite.
5. Section of *b. excentralis.*
6. *Belemnites tubularis.* Alum shale.
7. A species of lobster or prawn. Upper shale.
8. Fossil prawn. Oolite.
9. A kind of crab, resembling a beetle. Ditto.
10. Another species. Ditto.
11. *Ammonites perarmatus.* Alum shale.
12. ——— *maculatus.* Alluvium.
13. ——— *Redcarensis.** Lowest shale.

* This appears to be a smaller species than *a. Bucklandi*, which is also found in the lowest shale, both at Redcar and Robin Hood's Bay.

PLATE XV. *Fishes, &c.* P. 261, &c.

All from the alum shale.

FIG.
1. *Ichthyosaurus.* Fine specimen.
2. Another specimen.

FIG.
3. Another of a larger size, but less perfect.
4. A fin, or paddle, of the ichthyosaurus.

PLATE XVI. *Fishes, &c.* P. 261, &c.

All from the alum shale.

FIG.
1. Imperfect ichthyosaurus, with two fins.
2. Head of an ichthyosaurus.
3. Fragment of a head, shewing the order of the teeth.

FIG.
4, 5, 6. Specimens of vertebræ. No. 6 may belong to the *plesiosaurus*. See Geological Transactions, V. p. 582, &c.
7, 8. Pikes, with shining bony scales & plates.

PLATE XVII. *Teeth and bones of Quadrupeds, &c.*

All from Kirkdale cavern, except No. 1, which is from R. Hood's Bay.

FIG.
1. Elephant's grinder, very large.
2. Part of the jaw of a wolf.
3. Part of the pinion bone of a fowl,
4. Shank bone of a large quadruped.
5. Leg bone of a small quadruped; full size.
6. Grinder of the *palæotherium magnum.*
7. Another large grinder.
8. Grinder of a small palæotherium.
9. Grinder from the under jaw of an ox.
10. Half expanded molar tooth of an ox, or large stag.

FIG.
11. Part of a jaw, with two grinders, of an unknown animal.
12. Grinder of a rhinoceros.
13. Part of a stag's horn.
14. Fetlock bone of a quadruped.
15. Jaw of a hyæna, with the teeth.
16. Small rib; probably of a rat, as the jaw of a rat from the cavern is in the Rev. J. Smyth's collection.

☞ The Binder will place the Map, Section, and Lithographic Plates, at the end of the Work, immediately before the Index; and is requested not to *beat* the Plates.

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